The
Practical Engineer

A monthly journal, devoted to the economical generation and utilization of power and to the interests of stationary engineers

VOL. IX. PHILADELPHIA, MARCH, 1905. No. 2.

OFFICE, ELECTRIC DEPT.

STEAM ENGINE PRACTICE AND DESIGN

Different Types of Pistons and Packings as Found in Modern Engines

Fig. 1.

In the design of a steam engine, the piston and piston packing should require more than passing notice, as its work is performed within the innermost part of the cylinder, hidden from observing eyes, where, if it is not designed properly, waste of steam and deterioration of the cylinder will take place unnoticed. On account of the various amounts of cylinder condensation and re-evaporation of the steam in the cylinder, it is impossible to determine accurately from an indicator card whether steam is leaking past the piston; so that a design which insures tightness is to be desired. It must also be designed so that while maintaining this tightness, the effect of friction on the piston and cylinder will be a minimum. These facts have, of course, been appreciated by engine builders and there has been no part of an engine which has received more of its share of attention than it has, which accounts for the various designs to be found in practice.

Fig. 2.

In general, a piston is a cylindrical piece which slides backwards and forwards inside a hollow cylinder. As applied in the steam engine, it receives the pressure of the boiler upon one side of it, until cut-off takes place, after which the gradually reduced pressure, due to expansion, acts upon it, until release takes place, its other side being open to the exhaust which may or may not be the pressure of the atmosphere. This unbalanced pressure on the piston is transmitted through the piston rod and connecting rod to the crank pin where the work of reciprocation is transformed into work of rotation. The piston must therefore be strong enough to transmit the work required of it; it must be long enough to allow a sufficient area of the piston to bear against the cylinder efficiently

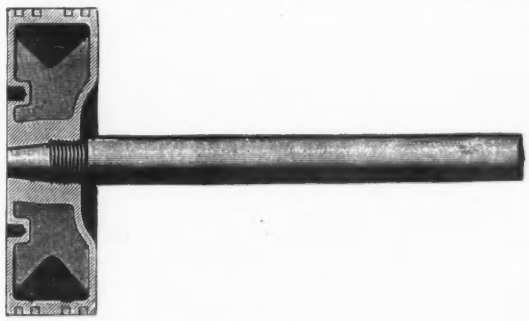


Fig. 3.

and accommodate the packing devices which fit the bore steam tight, and it must have some provision made in it for connecting the piston rod to it.

The simplest form of piston is a true cylindrical piece which fits accurately into another cylinder which is bored to fit. The piston used in a steam indicator is of this description. The leakage is diminished and the piston is lubricated by having a number of circumferential grooves cut in it. The objection to this simple form of piston is that there is no provision for wear and, therefore, for large pistons transmitting power, some other arrangement must be used.

In the early days of the steam engine, when the pressure of steam used was low, the piston was made steam tight by filling a wide groove on its circumference with hempen rope soaked in tallow. To permit of this packing, or junk, as it was called, being tightened up from time to time as it became worn, and also to allow of its being removed without withdrawing the piston, a junk ring was used. This junk or bull ring is still

used on many pistons in which metallic packing has taken the place of junk. Hempen packings soon went out of existence when higher pressures began to be used, as it becomes rapidly charred and worn under the high temperatures, although it is still used for pump pistons and buckets. With the introduc-

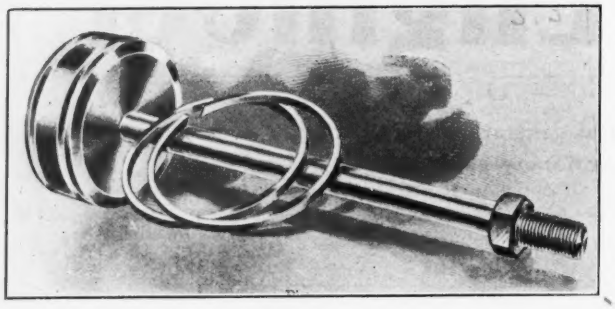


Fig. 4.

tion of high pressures and more perfect workmanship, metallic packings began to be used and are still used in all types of steam engine in some form or other.

The materials out of which pistons are made are usually cast-iron, wrought-iron, brass, bronze and cast-steel, but all modern stationary engines are equipped with cast-iron pistons, the other materials being used in high speed marine or special engines where lightness combined with toughness, flexibility and strength are factors of consideration.

On account of the many practical considerations which enter into the design of a piston, it is not calculated for strength according to the usual methods, but it is given a length and thickness which are the result of experience and depend also upon

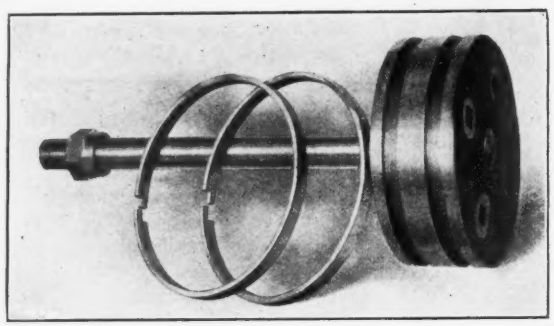


Fig. 5.

the kind of packing used. It is usually made in one of three forms: the solid piston, which is only used in small engines, where the weight saved by making it hollow would be negligible; the box piston; and the spider and follower piston.

The most usual method of making the piston steam tight is by means of rings which fit in grooves turned in the bearing surface of the piston. They are made so that they shall fit their grooves on the sides so as to prevent leakage around them and at the same time press outwards with sufficient force to prevent steam leakage. The rings differ in design according to the kind of metal out of which they are made and according to the number of them used.

By far the most piston rings are made out of cast-iron although steel and composition metals are used. The advantage claimed for the composition ring which is made out of brass, bronze or babbitt metal, is its softness, so that any wear which comes upon it will affect it rather than the bore of the cylinder. The advantages of steel rings are their elasticity and toughness, but their tendency to cut the cylinder because they are so hard has caused them to be little used. The cast-iron ring has the advantage of cheapness; it has the same hardness as the cylinder surface against which it rubs, and its elasticity is a valuable feature.

As the rings are made elastic, so that they can take up the wear on the cylinder or on themselves, they must be made with joints in them. There are various kinds of joints used, as shown in the accompanying illustrations, such as the scarf or tongue joint, but whatever the form of joint employed, it is usual, when two or more rings are used, to stagger them so that in case steam should leak past one joint, it is made as difficult as possible for it to leak past the other joints.

There are various methods used in practice to keep the piston rings tight against the piston. The one that is most generally employed with box pistons is called the snap ring, which

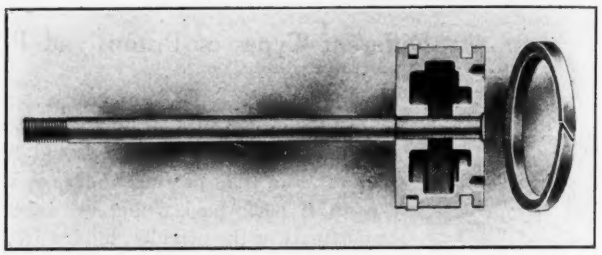


Fig. 6.

depends upon the elasticity of the metal itself. It is made by turning the ring to a diameter larger than the diameter of the bore of the cylinder, usually in the proportion of ¼-inch larger per foot in diameter. The finished ring is then cut apart and sufficient metal is taken out so that when squeezed together it will just fit the cylinder. It will then tend to regain its original diameter which creates sufficient pressure to make a tight joint. The radial pressure against the bore is maintained constant throughout the circumference by making the thickness of the ring different at different distances from the joint.

Another method used with large vertical engines or medium sized horizontal engines is to force the packing ring out by an

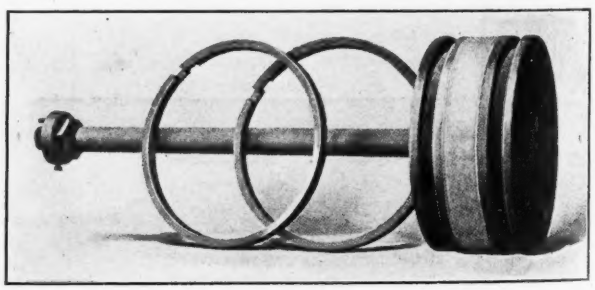


Fig. 7.

inner or spring ring. A favorite design for large horizontal engines is to have flat springs push radially outwards at several points on the inner circumference of the ring. These springs can be adjusted so as to regulate the tension, and in horizontal engines the lower springs have a greater tension than the upper ones, as the lower ones must carry the weight of the piston.

Another method is arranged so that the ring is pushed out by means of screws or wedges, as the surfaces wear, and still another method takes advantage of the pressure of steam to keep the piston rings tight against the cylinder. In this method, the groove underneath the piston ring is connected at several points through small holes so that the packing ring is forced outwards by the pressure of the steam behind it.

There are various methods of fastening the piston rod to the piston. The principal ones are shown in the accompanying illustration. The piston rod is sometimes threaded and the piston screwed on it, the joint being prevented from unscrewing by the use of a jam nut, or the end of the rod is riveted over. The piston rod is sometimes made with a shoulder and a tapering surface which fit into a tapering hole and the joint is drawn up tight by means of a strong nut, the nut taking the pull on the piston and the tapering surface taking the push. Another method is to fasten the piston and rod together by means of a cotter which goes through both at right angles to the rod.

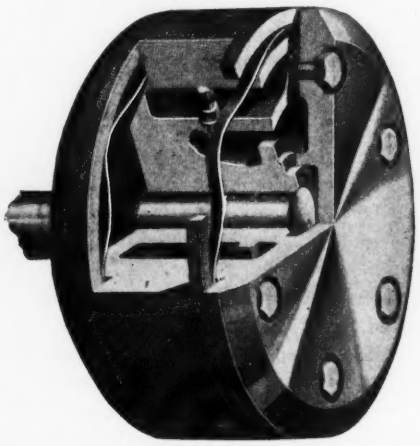


Fig. 8.

When this plan is adopted it is only applicable to follower pistons. The key is placed within the hollow part of the piston and therefore requires no clearance. Still another method used is to taper the rod which fits a tapered hole in the piston and rivet the end over, or the piston is sometimes shrunk on the rod. When this latter method is used, the hole through the piston is bored slightly smaller than the diameter of the rod. The piston is then heated to low redness, whereby the hole is expanded sufficiently to permit the rod to enter it and when it contracts the pressure makes a very tight joint.

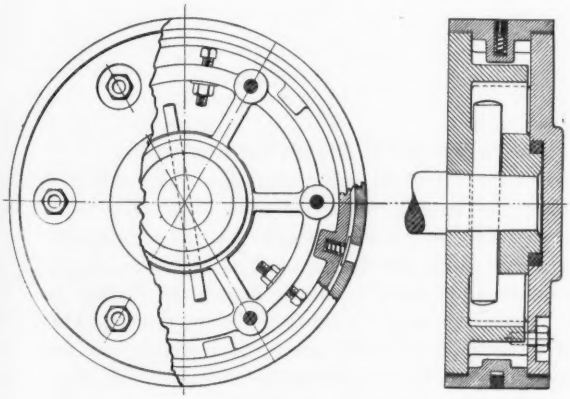


Fig. 9.

The various designs of pistons, piston packings and piston rod connection used on modern engines are shown in the accompanying illustrations. Fig. 1 represents a box piston used on the Harrisburg engine. The snap rings are made of close grain charcoal iron and are sprung into grooves. The piston end of the rod is tapered, driven home to a shoulder and secured by a heavy nut which is drilled and cottered to prevent its working loose. Fig. 2 represents the piston of the Chandler and Taylor high speed engine. It belongs to the box type which is cast hollow and uses two cast-iron snap rings for packing. The piston rod is screwed into the piston its whole length and the end is riveted over. Fig. 3 represents an Ames piston, which is also a single cored casting, and is packed by four snap rings sprung into grooves. The piston is secured to the rod by a thread and taper fit shrunk together to prevent coming off. Fig. 4 represents a piston used by the Erie City Iron Works on their engines. It is very similar to those above-mentioned except the method of connecting the rod to the piston. In this case, the rod is secured to the piston by a forced fit under hydraulic pressure, the end being riveted over into a countersink.

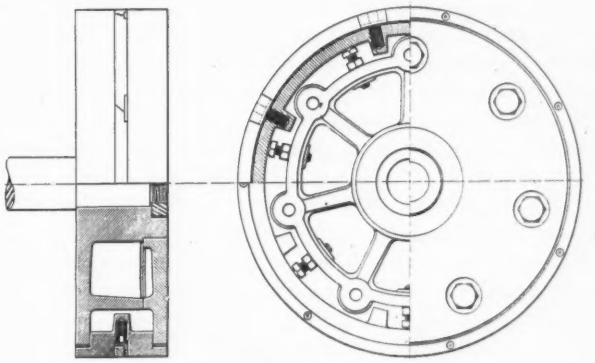


Fig. 10.

The piston used on the Russel engine, as shown in Fig. 5, differs somewhat from the usual run of box pistons. Two snap rings are used but between them is placed a band of anti-friction metal which acts as a shoe or carrier of the weight of the piston. The anti-friction band is supposed to expand just enough more than the iron of the piston to prevent the iron from coming into contact with the cylinder walls, and the snap rings do the packing. Fig. 6 represents a piston used on the Leffel engines. It is made of the hollow box pattern without any supporting ribs. The usual form of snap ring is used for packing. The piston rod is turned to a tight forced fit with a shoulder against which the piston is forced, the end of the rod being riveted to hold it firmly in place. Fig. 7 represents a type of piston used on the vertical engine of the Bayley type. It belongs to the hollow box type with cast-iron snap rings, the piston rod being fitted to the piston and riveted.

The above-mentioned pistons are representative of the types used on all high speed engines. With the slow speed Corliss engines, which involve large diameters of cylinders and therefore very much larger and heavier pistons, different constructions of piston and methods of packing are adopted. Fig. 8 represents a piston used on the Hewes and Philips Corliss engine. The piston proper is a strongly ribbed casting, fastened

to the piston rod by forcing, and further secured by a key and the end of the rod riveted. When any wear occurs and the piston gets out of centre, the piston can be centered by suitable screws and jamb nuts which bear against a bull ring. The bull ring is a solid casting turned in such a manner as to have a full semi-circular bearing on the lower half of the cylinder. At each end of the bull ring, narrow piston rings are used,

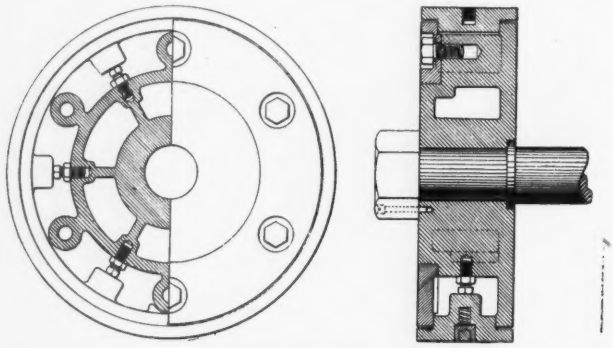


Fig. 11.

which, when the engine is first started, are set against the cylinder by their own elasticity but as they become weak from wear, crimpled springs are placed in the spaces underneath the rings, which gives them the proper amount of tension to insure their correct operation until they are worn out. The adjustment for alignment is made by removing the follower and setting up the screws provided for this purpose.

The St. Louis Corliss piston is shown in Fig. 9. It is made in three parts: the head, the follower and the bull ring. The bull ring is provided with a sectional packing ring, kept steam tight by means of bronze keepers and held in place by non-corroding coil springs. The piston is ground to gauge, the piston shrunk on and keyed, and the piston rod riveted over.

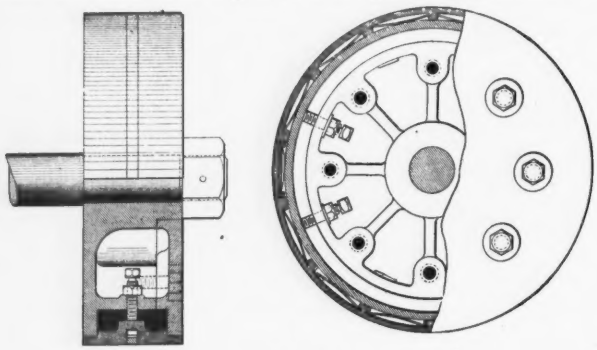


Fig. 12.

Fig. 10 represents the Harris Corliss piston, follower, junk and packing rings. In this style of piston, the junk ring extends over the full width of the piston, overlapping the piston and follower. It is grooved to receive a segmental packing. The piston is fitted with bronze adjusting screws so that the piston can be kept central and the rod may be always in alignment. The piston is forced on the rod by hydraulic pressure and a steel collar is screwed on the end of the rod.

The Fulton Corliss piston, shown in Fig. 11, is very similar to the St. Louis Corliss piston, the principal difference being the piston rod connection. The Fulton piston is pressed on the rod with a force considerably in excess of the total steam pressure and is locked on the end with a heavy nut which is pinned to prevent turning. Fig. 12 represents the Eclipse Corliss engine piston. The piston has a light spring packing with a narrow self-acting central packing ring. The whole weight of the piston rests on a solid junk wearing ring, adjusting screws being provided so that the piston can be maintained central. The piston is forced on up to a shoulder on the rod and is held in place by a nut which is pinned to prevent rotation.

The pistons above shown, are representative of the principal types of pistons in use to-day, and while there are hundreds of different makes of engines, the pistons used come under the classification named above and vary in slight detail of construction only.

Suction Gas as a Motive Power.

Suction gas is a semi-water gas and burns with a faint blue flame. It may be produced from any hard coal, coke or anthracite, if the fuel leaves no considerable amount of incombustible residues, and if the gas itself is free from tarry mixtures. In commercial suction gas plants, anthracite or coke is generally utilized.

In Europe, the suction gas motor is at present the most economical artificial source of power as far as the consumption of fuel is concerned. Engines from four up to several hundred horse power are in operation throughout the industrial countries of Europe in considerable numbers and show marked economy in coal consumption.

The operation of the suction gas system is as follows: Air laden with water vapors is passed through a column of red-hot coals. The carbonic acid produced by the imperfect combustion of the coal is reduced to oxide of carbon, the water vapors decompose into hydrogen and carbonic acid and the latter is also for the greatest part changed into oxide of carbon. The mixture of gases thus obtained passes through cooling and purifying devices and then enters the engine.

The gas is sucked into the motor and as it has only a low heating value, it must be compressed to very high pressures. For perfect combustion the gas requires 1.25 times its volume of air. It is claimed that the cost of fuel is about 50 to 60 per cent. less than in a steam plant. Its principal disadvantage is the trouble in starting and the great care that must be taken with all the numerous parts of the system.

Measuring Alternating Currents.

The amount of work given out by an alternating current dynamo or the amount absorbed by any alternating circuit cannot be measured in the same way as the power in a direct current circuit. With direct currents it is only necessary to read the ammeter and voltmeter and the product of the two readings is the number of watts transmitted in the circuit. Owing to the difference in phase between the impressed voltage and resultant current in an alternating current circuit, the results obtained by multiplying the volts and amperes would greatly differ from the true number of watts in the circuit.

In measuring the power of alternating currents, a wattmeter must therefore be used.

The tension of the drum spring of an indicator should be adjusted according to the speed of the engine, increasing for quick running, and loosening for slower speeds.

THE STEAM TURBINE PROBLEM

Some Advantages and Disadvantages of this Type of Prime Mover

The steam turbine, at the present time, is making large inroads in the reciprocating engine field, many power houses being equipped with this type of prime mover. As the turbine industry practically originated in 1884 in England and in 1895 in this country, it might be well to look into a few of the claims which have caused this type of prime mover to become so extensively used.

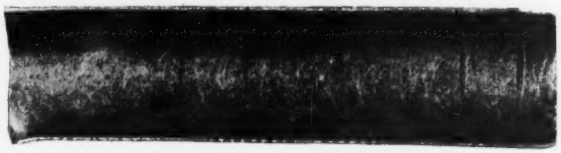


Fig. 1.—Enlarged View of concave side of new Parsons Turbine bucket

Fig. 2.—Same bucket after having been in use less than one year

In this country there are three types of turbines which have the widest use: namely, De Laval, Parsons and Curtis. The De Laval turbine belongs to the impact type, in which by means of a nozzle, the pressure of steam is expanded to a lower pressure, thus obtaining a very high velocity of steam, which is allowed to strike a single bucket wheel. With this construction a high disc speed is necessary which ranges from 10,000 to 30,000 revolutions per minute. As this speed is not applicable to present day machinery, it is geared down to a ratio of 10 to 1.

The Parsons turbine runs at a much lower speed than the De Laval, so that ordinary machinery can be connected directly to it. It depends upon the reaction principle rather than impact, and guide vanes take the place of expanding nozzles. It makes use of a large number of vane wheels mounted in series upon a single shaft. The steam in passing through the turbine expands, the residual energy left in the steam after passing through each ring of buckets being used in the next set of buckets and so on to the exhaust.

The Curtis turbine makes use of both the impact and reaction principle. With this type two or more stages are employed to carry out the total range of expansion from boiler to condenser. Each stage comprises a set of expanding nozzles and a wheel carrying more than one row of buckets. The velocity of the jet is reduced by interposing a set of guides which re-direct the steam leaving the first row of moving blades into a second set, and this process is carried out as many times as may be necessary to absorb the initial velocity of the jet. Thus the steam in each stage is alternately accelerated in the nozzle and retarded in the blades. As this makes use of a large wheel so as to get slow shaft velocities, this type of turbine is made with its shaft vertical.

Having discussed briefly a few of the fundamental principles found in each type of machine, the advantages claimed for the turbine are as follows: Simplicity of construction, compactness due to high speed, small foundations, reduced cost of oil and increased efficiency. The disadvantages are the high peripheral speeds, the use of large numbers of vanes, the wear and tear on the buckets and bearings and the superheating and condensing plants which are employed to obtain maximum economy.

The advantage of simplicity disregards the complexity of construction, as it is claimed, there being only two elementary parts, one stationary and one moving, it need not be considered so long as it operates successfully. The compactness is largely due to high speed of the turbine. This is a particularly valuable feature where ground is expensive, or space for extension is small. The advantage of a small foundation is its first small cost and its adaptability to places where a large engine foundation would be impossible. Only a foundation strong enough to withstand the dead weight of the turbine is sufficient, as all reciprocating stresses and vibrations are absent in a turbine. As no oil is used in the interior of the turbine, not only is its cost saved but the condensed steam is pure water and can therefore be returned directly to the boiler. The increased efficiency when running lightly loaded seems to be an advantage which a turbine possesses over a reciprocating engine, the steam consumption of each type being approximately the same when running under full load.

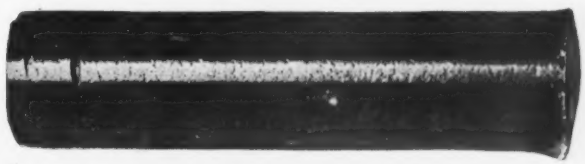


Fig. 3.—Convex side of same bucket when new.

Fig. 4.—Same blade showing wear on convex side.

One disadvantage of the turbine is its high peripheral speed, which together with its necessarily small clearance between the moving parts, makes the workmanship very exacting. Any small wearing out of line of any of the moving parts will result in disaster. Cases have been cited where turbines have not been shut down because it was feared that the decreased temperature due to cooling off would warp the moving parts out

of line. The disadvantage of using a large number of vanes would be principally its first cost and cost of repairs. A 300 kilowatt Parsons turbine contains altogether 31,073 blades, of which 16,095 are moving blades, and if many of these are worn and have to be repaired, the cost of doing it together with the time necessary for the repair must necessarily be considerable. The disadvantage of the superheater and condensing sets is that they are not only costly but they detract considerably from the argument that the turbine saves space.

At a recent meeting of the Franklin Institute, Philadelphia, the subject of the steam turbine was discussed, in which its many advantages as mentioned above were brought forth by those interested in steam turbines, but on account of the apparent lack of interest on the part of those favoring the use of the reciprocating engine, many of its disadvantages were not mentioned, although the following remarks were made by an engineer, showing the wear on the turbine blades:

"In general it is claimed by engineers strongly advocating the reciprocating steam engine for central stations, that the merits of the steam turbine under the most ideal and satisfactory conditions only, have been generally given and that the defects and faults have not been generally brought out. The reciprocating steam engine has been developed to a high state of perfection and has been thoroughly tested as to efficiency and durability while the steam turbine is practically new and untried by years of service as compared with the reciprocating engine.

It is true that this argument might be brought forth in reference to any new invention but the advocates of the reciprocating steam engine hold that all has not been told as to the defects of the steam turbine, especially as to its durability; and that the claim as to the cost of installation has been overestimated, as compared with reciprocating steam engine units. When the total cost of the additional size of the condenser, pumps, superheater and other auxiliary apparatus is considered, as well as the sapce they occupy, there is little to be said in favor of the steam turbine on these points.

Fig. 5.—Enlarged View of De Laval turbine bucket in use less than 6 months.

As to the cost of maintenance and repairs, it is claimed that there is an enormous wear on the back of the turbine blades or buckets on account of wire drawing of the steam and the accompanying illustrations show the effect on the steam turbine buckets of De Laval as well as the Parsons type and also show the wear on the De Laval steam turbine pinion. Fig. 1 represents an enlarged view of the concave side of a new Parsons turbine blade and Fig. 2 represents the same blade after having been in use less than one year. Fig. 3 represents an enlarged view of the back or convex side of the same blade and Fig. 4 shows the wear on that side. Fig. 5 shows an enlarged view of a De Laval nickel steel bucket which was in use less than six months. From these views, it is quite evident that the wear upon both the De Laval and Parsons blades is considerable. The effect of wear upon a helical steel cast pinion as used in the De Laval turbine is shown in Fig. 7. Fig. 6 represents the pinion when it was new and Fig. 7 is a picture of it after it had been in use about six months and shows that the profiles of the teeth are considerably worn away by wear.

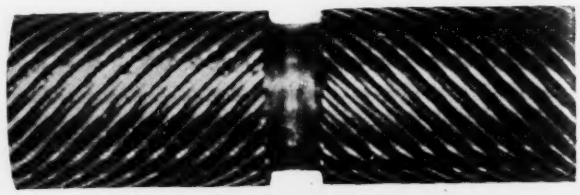


Fig. 6.—New De Laval cast steel pinion.

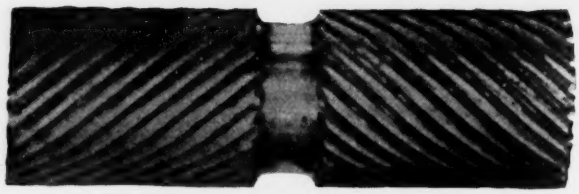


Fig. 7.—Same pinion after having been in use 6 months.

If the turbines were tested with the blades in the condition shown in the illustration, or after there had been considerable wear on them, a large amount of steam would pass them without being effective, and the efficiency would be very much lowered. It might be stated that the accompanying illustrations were supplied by a leading engineer in Europe, who strongly favors the reciprocating engine and whether they apply only to turbines constructed and operated under the worst conditions cannot be stated, but it seems a fact that turbine blades do wear considerably, which is supposed to be lessened by superheating the steam, but before any owner of an engine replaces it on the score of economy, the durability and economy of the turbine after years of service should be fully known."

———o———

How to Centre an Engine.

The "dead centre" is the point in the stroke where the crank and piston rod are in the same right line. To find dead centre, turn engine in the direction it runs until cross-head is within a short distance of its limit of motion. Mark guide at end of cross-head shoe. Mark some revolving circular part of engine, as disc crank or fly wheel, and place one point of a fixed tram in this mark and the other on some fixed object in line. Now turn engine past the centre in the direction she runs until end of cross-head shoe passes mark on guide. Turn back till shoe reaches mark. Holding tram still on the fixed object, place other point on selected revolving part and mark as before. Bisect distance between marks on revolving part and turn engine till point of tram rests on central mark, and the engine is on "dead centre."

VERTICAL HIGH POWER STEAM ENGINES

European Application of the Vertical Engine in Central Station Practice.

It is generally conceded that the high speed vertical compound engine has been more extensively used and has been developed to a higher state of perfection in England than in any other country, either in Europe or America. The low speed engines of large power are also mostly of the vertical construction in the larger stations of England, almost to the exclusion

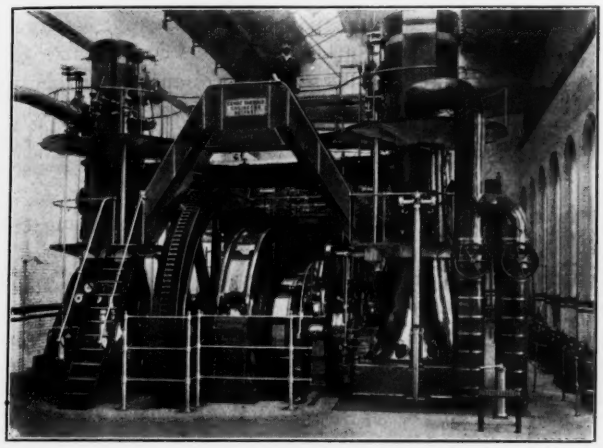


Fig. 1.—1300 H. P. Cross Compound Vertical Engine at Hudderfield, England.

of the horizontal types. The accompanying illustration, Fig. 1, shows a 1300 horse power compound engine of the vertical type directly coupled to a continuous current generator and installed at the electric station at Hudderfield, England. The vertical cross compound engines shown in Fig. 2 are in operation at the power plant of the Mersey railway in England.

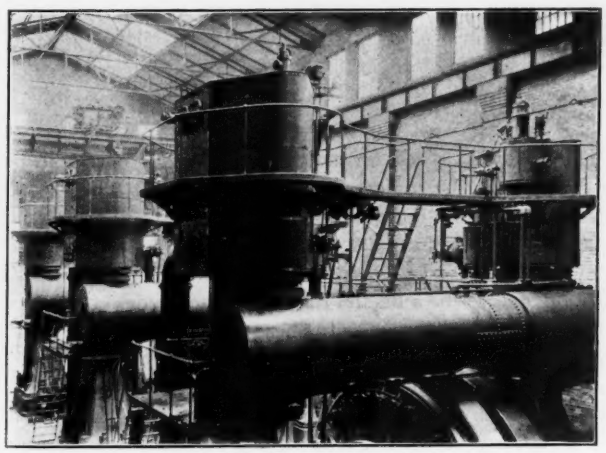


Fig. 2.—Vertical Engines at Power Plant of Mersey Railway, England.

In Germany, until recently, the horizontal type of engine was more extensively used and either tandem or cross compound high power engines of this type will be found in most of the central stations there. Vertical engines of the marine type are now, however, becoming more widely used, an example of which is shown in the accompanying illustration, Fig. 3. This vertical compound engine is directly coupled to a 600 horse power fly wheel generator.

In France, the vertical cross compound engine is also extensively employed, especially in Paris, where the saving of floor space is essential on account of the high cost of the land. The accompanying illustration on the front cover shows a number of 1300 horse power vertical compound engines and generators at a French power plant at Jemmapes Wharf in Paris.

The question of space occupied by large units in central stations in cities, such as New York, Chicago, London, Paris and Berlin, is of the greatest importance and this largely accounts for the installation of the vertical cross compound engines in these power plants. The steam turbine occupies somewhat less space than the vertical reciprocating engine and where this feature is of importance it is likely to replace the latter as the

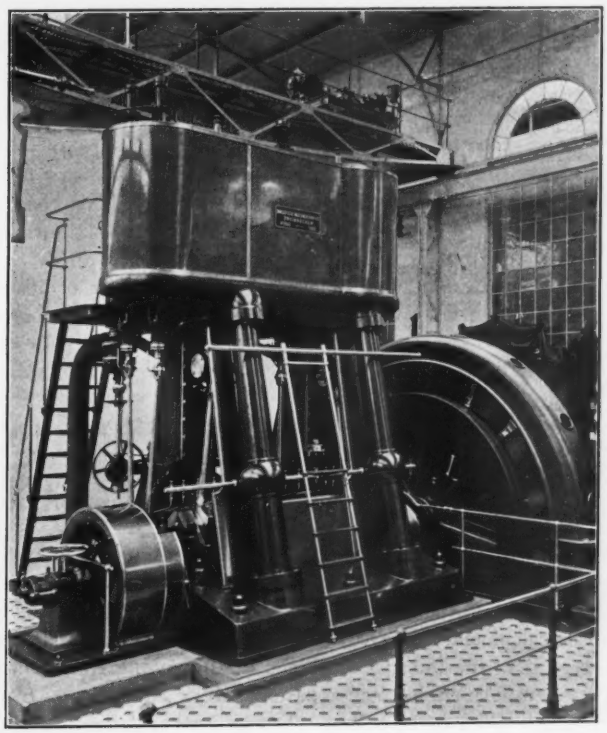


Fig. 3.—600 H. P. Vertical Engine of the Marine Type used in Germany

vertical reciprocating engine has taken the place of the horizontal reciprocating engine in power plants located in congested districts even if it is not as economical or serviceable as it is said to be.

It may be of interest to consider the installation of the Jemmapes power plant at Paris, shown on the front cover, which is installed on the five-wire system. This plant was designed for a total capacity of 28,600 horse power, consisting of 22 units, of 1300 horse power each. The plant was constructed on the Saint-Martin Canal, on a site of a trapezoid shape, 280 feet in depth with a front of 190 feet on the wharf.

On account of the large output required and the small area available it was not possible to adopt the usual custom of placing the engines on the same floor with the boilers. The engines and electrical generators are installed on the first floor, four boilers for each unit on the second floor and the storage for the fuel on the third floor. A gallery is provided for the switchboards and feeders communicating at the right and left with the engine room staircases. The installation of the auxiliary apparatus, which consists of pumps, coal elevators, hoists, etc., is in the centre of the plant but separated from it by a passage 16 feet in width.

The coal is delivered to the station in boats and is mechanically unloaded, brought to the foot of the elevator and dumped automatically into the hopper of the elevator, which carries it to the top of the building. The usual endless chain conveyors are employed, operated by electric motors. The feed water is taken from the city mains, filtered, and metered. It then passes to an underground reservoir with four compartments having a capacity of 45,000 cubic feet. Electric motor driven pumps raise the water to storage reservoirs under the boilers to be fed. The condensation water is taken from the canal above the power plant through a pipe 45 inches in diameter which passes into a canal around the outside walls of the station. Each set of four boilers feeds the vertical steam engine installed directly below it, the quantity of steam used by each unit being about 17,000 pounds per hour.

The boilers are of the tubular type, each one being capable of supplying 5500 pounds of steam under a pressure of 120 pounds per square inch. A steam superheater, as well as a feed water heater, is provided for each boiler. Each boiler has a fire grate surface of 56 square feet and a total heating surface of 2340 square feet. If found necessary, three boilers can supply a single unit with sufficient steam but under ordinary circumstances four boilers are utilized. A peculiar arrangement of this boiler plant is that each 1300 horse power unit and its group of four boilers are distinct and separate, there being also a separate chimney for each group of boilers.

The electrical generators are each capable of supplying a current of 1500 amperes at 500 volts or 1200 amperes at 600 volts and are driven at a speed of 70 revolutions per minute. They are of the inner pole type, the current being collected on the periphery of the revolving armature. There are twelve sets of brushes used in collecting the current, which are mounted on a spider. The field consists of twelve poles of forged iron mounted on a mild steel yoke. The current from the generators is delivered to a number of sub-stations. One of these sub-stations has four stories above ground and three underground, the latter being equipped with storage battery installations. Each of the underground floors contains four batteries of 280 cells each with five boosters and a switchboard. The batteries have a capacity of 2200 ampere-hours, the normal discharge rate being 300 amperes. The boosters are four pole machines separately excited, two machines being mounted on the same shaft.

The vertical compound engines are of the condensing type with Corliss valve gear and give out 1300 horse power at a speed of 70 revolutions per minute. The cylinders are both steam jacketed, the jacket of the high pressure cylinder receiving the steam directly from the boilers and the jacket of the low pressure cylinder constitutes an intermediate receiver between the two cylinders, the jackets having automatic petcocks. The cylinders are 31.5 and 53 inches in diameter with a 47-inch stroke. The shafts are constructed of mild steel and weigh 10 tons. They carry a fly wheel 19 feet in diameter, weighing 31 tons on one end and the dynamo on the other, there being two outside and four intermediate bearings. Each engine is surrounded by a gallery, a stairway being provided near the fly wheel.

DEFECTS IN INDICATOR CARDS

Discussion of Admission, Cut-off, Release, Back Pressure and Compression

An indicator card, besides giving the mean effective pressure on the piston of the engine by means of which the horse power can be calculated, also gives useful and interesting information in regard to the internal workings of the engine from which it is taken. An engine may apparently work satisfactorily from an outside point of view, but, when its internal affairs are examined, it may be found that numerous changes can be made which will affect considerable saving in the coal pile. It may be that the cut-off is taking place too late, or too early, release may be too early or too late, compression may be too early or too late, or admission may not take place at the proper time.

Whatever faults there are in the setting of the valves, the indicator will usually show it, provided that the indicator motion exactly represents the reduced motion of the piston and that the type of engine is taken into consideration. A faulty indicator motion has often resulted in giving cards which were far from the truth and some very peculiar results can often be explained away by examining the indicator motion.

The best way to test an indicator motion for correctness is to connect up the indicator with the string attached to the motion. Leave out the spring of the indicator so that the pencil point can be moved up and down by hand. Put the engine on one of the centres and mark a line on the card when in that position, and scribe a line on the cross-head guides corresponding to some mark on the crosshead. Put the engine on the other centre and mark a line on the guides corresponding to the same mark on the crosshead and mark another line on the card. Then divide the distance between the two marks on the guide into say 10 equal parts. Bring the mark on the crosshead opposite each mark on the guide and draw a line on the card for each position by moving the pencil up and down. There will then be as many marks on the indicator card as there are marks on the crosshead guide. If the indicator motion is a correct one then the lines on the indicator card should be exactly equal distances apart, showing that for each 1-10 travel of the piston, the barrel of the indicator revolves 1-10 of

the length of the card.

When a trunk engine is tested or an engine whose crosshead is enclosed, other methods of putting the engine on centre and dividing the stroke into equal parts must be used. This can usually be accomplished by attaching a heavy bent wire to the crosshead and noting its maximum travel upon a board placed near it, and by dividing the distance between the marks into some number of equal parts, the wire can be brought opposite each of the marks on the board, at the same time drawing lines on the indicator card to correspond to each position of the piston.

which the card is taken must be known. For instance, it is not to be expected that a throttling engine or a simple slide valve engine will give as good a card as a four valve engine, and what might be a good card for the slide valve engine would be a bad card for the four valve engine. Fig. 1, Fig. 2 and Fig. 3 represent cards which may be said to be good ones as representing each class of the three engines mentioned. Fig. 1 was taken from a throttling engine, Fig. 2 represents a card taken from a slide valve engine, and Fig. 3 represents a card from a four valve Corliss engine.

There are certain features about indicator cards taken from

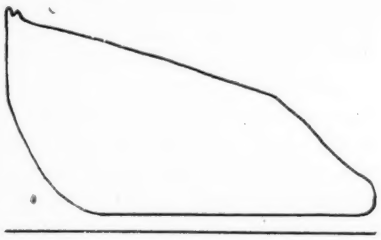


Fig. 1.

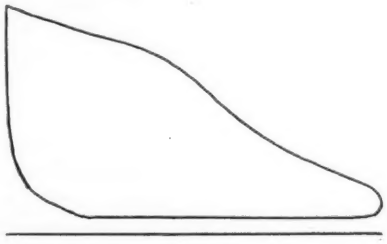


Fig. 2.

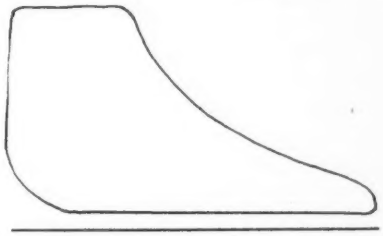


Fig. 3.

It is with the trunk or half-trunk engine, or with an enclosed crosshead that the greatest care must be taken to obtain a correct motion, because it frequently happens that a regular pantagraph or reducing motion cannot be used, so that other devices, such as placing a small eccentric on the protruding shaft, have to be utilized and there is far more danger of obtaining incorrect motions from these types of motions than from any others, and hence the importance of testing the motion. All indicator motions should be tested at some available time when the engine is shut down, so as to be sure that the events which take place in the cylinder are recorded at the proper moment.

After it is assured that the indicator motion is correct, the indicator spring should be tested for accuracy. Whether it is stronger or weaker than the scale which is marked on it will not affect true position of cut-off, release, compression and admission, but will only give a higher or lower horse power, since the scale of the spring is different from that marked on

any engine that should never be allowed to take place. The admission line which shows the manner in which steam is admitted to the cylinder is one of the most usual lines which can be improved on an indicator card. Figs. 1, 2 and 3 each show an admission line which is perpendicular to the atmospheric line and under normal conditions this is a correct admission. In order that it should be perpendicular, the steam valve must be open so as to admit the full pressure on the piston before the piston starts on its new stroke. To do this the valve must be given some lead, which is the amount the steam port is open when the engine is on centre. When steam is admitted late, the card will often look like that shown in Fig. 4, where the admission line curves inward, instead of being vertical. Fig. 5 represents an indicator diagram of an engine which has too early admission. The admission line curves in, instead of being vertical, as it should be. The amount of compression is also sometimes responsible for the appearance of

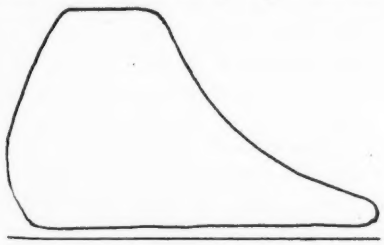


Fig. 4.

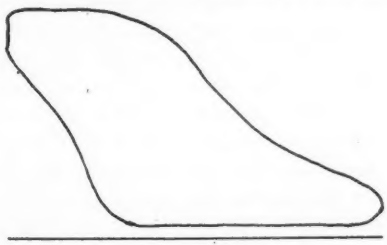


Fig. 5.

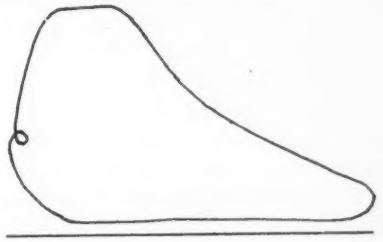


Fig. 6.

it. If a good indicator is purchased and the spring taken good care of, the amount that the spring will vary from its supposed strength will be almost negligible except in cases where the accurate efficiency of the engine is required. But in any case, whether or not it is weaker or stronger, it will not affect the useful information which it gives in reference to the internal workings of the engine.

A card may appear to be bad at first sight when in reality it might be as good as can be obtained. The kind of engine from

the admission line. The effect of this is shown in Fig. 6, which is produced by the pressure running up by compression and falling away when the piston starts on the forward stroke before the valve is open.

When the loop occurs at the top of the diagram, as shown in Fig. 7, it is sometimes unavoidable. Many high speed engines give a card like it when under light loads and even when they are sometimes loaded. Most high speed engines have a single valve which is regulated by a shaft governor. The

governor alters the movement of the valve so that under light loads the cut-off is made to occur early in the stroke. The effect of this is to make compression come early so that the pressure in the cylinder is greater than the initial pressure from the steam and hence the loop. This is unavoidable at light loads with such an engine, but should not occur when any load of consequence is thrown on the engine. A very common form of admission line is shown in Fig. 8, where there is a small peak on the admission line. Very often this peak is just a line without enclosing any area, and since it does not affect the area of the diagram, it does not affect the horse power. A peak like that shown in Fig. 8 is often caused by the momentum of the indicator parts, which can be avoided by using a stronger spring.

The steam line represents the pressure in the cylinder from admission to the point of cut-off, and if a line representing the boiler pressure be drawn above it, its height represents the percentage of boiler pressure utilized in the cylinder. Fig. 3 represents a very good steam line from a Corliss engine.

Fig. 2 shows what is considered to be a good steam line from an automatic high speed engine, while since Fig. 1 is taken from a throttling engine, its steam line must, of course, represent only a portion of the boiler pressure. There is not very much that an engineer can do with the steam line since the design of the ports and steam passages and the type of engine will determine what it will be.

The expansion curve of the steam does not exactly follow the above law because when the steam first enters the cylinder of a steam engine, some of it will condense so that its pressure will fall more rapidly than that due to expansion alone. When the temperature of the cylinder walls is equal to the temperature of the steam, the steam will stop condensing and instead, owing to the reduction of the pressure by expansion, the condensed steam will be re-evaporated, and for these reasons, the expansion line usually falls below the theoretical curve at the first stages of expansion, and above it during the later stages. The exception to this, in an unjacketed engine, is when the piston leaks steam. In that case the expansion line falls below what it ordinarily would by the amount of steam that leaks past the piston. Unfortunately, this is one of the things that it is hard to detect on an indicator card because the leakage might just be sufficient to lower the pressure which is caused by the increase of pressure due to the above-mentioned evaporation of condensation, so that the net result would give apparently an almost perfect card. In general, except to prevent the leakage of the steam past the piston, or through the valves, the engineer has very little control over the kind of expansion line the engine produces, if dry steam is admitted and the valves properly set.

The release line should always occur early enough before the end of the stroke to allow the steam in that end of the cylinder to be exhausted before steam is admittd on the other end. The effect of this is to give a sloping line like that shown from the card in Fig. 9. It is very much better to give the card a release like that shown in Fig. 9, than one like that shown in Fig. 10, because, since the steam must be exhausted from the cylinder, it is far better to do it before the piston reaches its dead point than afterward, because in the latter case there is a considerable back pressure on the piston at a time when it is not wanted. Fig. 11 shows a sample card which is often met with and that is, when cut-off occurs at such a point in the stroke that the expansion and back pressure line just meet when release takes place. Fig. 12 shows a card taken from a Corliss engine with an early cut-off.

Fig. 7.

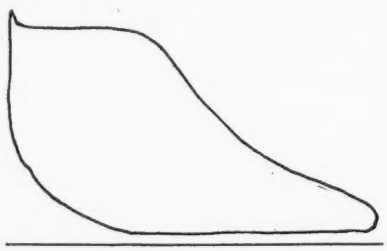


Fig. 8.

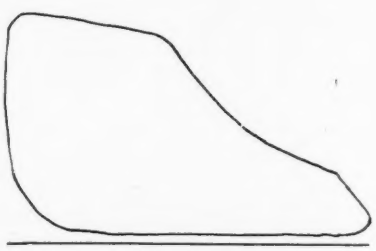


Fig. 9.

The cut-off in an automatic engine takes place at different portions of the stroke, depending upon the load, and it is the aim of all designers to give the valve a sharp cut-off, which will give a sharp point on the diagram where the steam line and expansion line join. This is more nearly accomplished in the four valve type of engine than any other because the valve closes from its full opening to zero in the shortest possible space of time. This cannot be done in a single valve engine because there must be an interval between the time when the port is wide open and when it is closed, which means that the steam must necessarily be throttled, which means a fall of pressure in the steam cylinder, and hence a rounded corner for the cut-off. To overcome this as much as possible the valve is given some overtravel, which makes the valve move faster on its seat when it is about to cut-off.

The expansion line should, as far as possible, conform with a curve known as an equilateral hyperbola; that is, the curve should decrease in pressure inversely proportional to its increase in volume. For instance, suppose an engine to cut-off at ¼ stroke, the pressure in the cylinder should be reduced to ½ when the piston reaches ½ stroke, 1-3 when the piston reaches ¾ stroke, etc., because the product of the pressure multiplied by the volume should always give the same result.

In this case the expansion line crosses the back pressure line and when release occurs there is a negative pressure existing in the cylinder, so that the pressure of the atmosphere is admitted at release instead of the steam pressure being released to the atmosphere. The area of the loop represents negative work, that is, it represents work which the fly-wheel gives out during that portion of the stroke and in calculating the work done by the piston, the area of the loop must be subtracted from the larger area of the diagram in order to get the effective work of that stroke.

The negative loop should be avoided wherever possible. With an engine running under variable loads which are rapidly

changing, it is often impossible not to get such a card as shown in Fig. 12, but if an engine must run under these conditions for any length of time, a reduction in the boiler pressure will give a later cut-off and hence the expansion line will be higher than the back pressure line and the loop will disappear.

The exhaust, or back pressure line should be as near to the atmospheric line as it is possible to get it in a non-condensing engine and as far below the atmospheric line as it is possible to get it in a condensing engine. In well designed engines

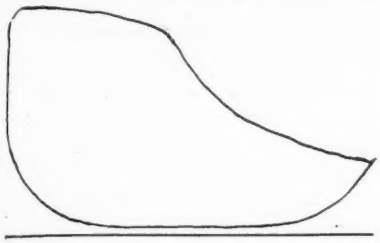


Fig. 10.

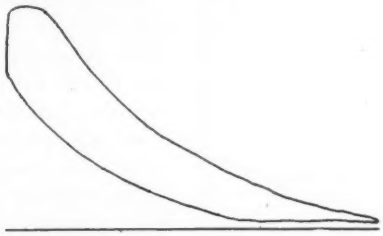


Fig. 11.

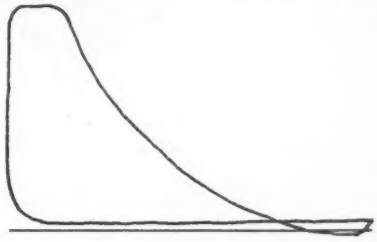


Fig. 12.

which run non-condensing, the back pressure lines should coincide with the atmospheric line, but where small ports are used and long exhaust pipes full of bends, the back pressure line will be well above the atmospheric line. The elevation of the back pressure line above the atmospheric line represents lost work in every case.

The compression line of an indicator card is one which involves a great deal of discussion. The primary object of compression is to furnish a cushion of gradually increasing resistance so that the moving parts may be brought to rest and started off in the reverse direction without the shock which would otherwise come upon them when the valve would be suddenly opened for admission. Its second advantage is the filling of the clearance spaces with steam that would be otherwise lost, thus increasing the economy of the engine.

The proper amount of compression depends upon the type and speed of the engine. High speed engines require more compression than low speed engines. In no case, however, should the compression pressure be allowed to exceed the admission pressure. In slow speed engines the compression

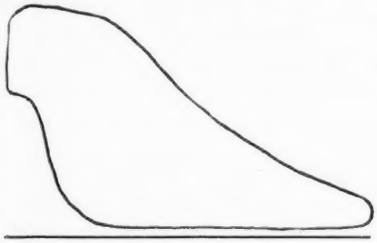


Fig. 13.

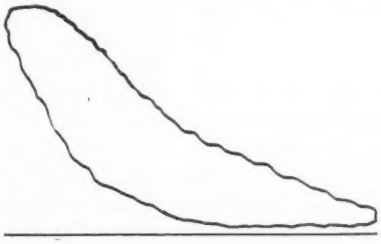


Fig. 14.

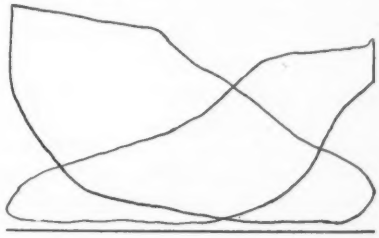


Fig. 15.

curve should join the admission line in a well rounded curve at about one-third of its height. The compression line of medium speed engines should meet the admission line about one-half way up and high speed engine compression lines should join the admission line about one-eighth of the height from the steam line. Other than these rules, the matter of compression is largely one of experience, as an amount of compression that will cause good results in some engines may be too much or too little in others.

A leak in the valve or piston will often cause a poor compression line, as shown in Fig. 13, because, as the piston approaches the end of the stroke, the pressure is diminished by leakage after the compression has attained a certain value, which causes the curve in the compression line until the admission of steam. When the compression is too early it forms a loop, as shown by the card in Fig. 7. This loop is also negative work and should be avoided whenever possible by reducing the amount of lead.

An indicator card is often composed of wavy lines, as shown in Fig. 14. This is usually due to the vibration of the indicator string and indicator parts, or the piston does not move smoothly in its cylinder. A heavy tension on the indicator cord and the avoidance of knots or wire connections will often stop the vibration of the string, and frequent lubrication and a stronger spring will generally stop the vibrations due to the indicator. When a card of this kind is taken, if the waves are even it will not distort the effective area, as the true line is one that goes through middle of the undulations, so that what is added on to the area by one wave above the line is subtracted by the corresponding wave below it.

One of the principal troubles encountered with steam engines is the unequal work performed in each end of the cylinder, as shown in Fig. 15, and it is a problem, especially with single valve engines, just what to do to remedy it. In taking cards from this type of engine from no load to full load it is often found that while at light loads, one end will do most of the work, at heavy loads, the other end does more work. The thing to do in this case is to set the valve so that the engine gives the best cards at the normal load of the engine. It is not a particularly serious matter if one end of the cylinder does give out a few more horse power than the other, so long as the steam distribution in each end is all that could be desired. In Fig. 15, the trouble would not be so serious if one end did not have too early an admission and the other end a too early exhaust closure. The proper thing to do in all cases is to obtain an equal horse power output in each end of the cylinder consistent with the best and most economical steam distribution.

The Practical Engineer

PUBLISHED ON THE FIRST OF EACH MONTH

L. L. RICE, Proprietor

46 North Twelfth Street Philadelphia, Pa.

The Practical Engineer is devoted to the economical generation and utilization of power for the industries.

Articles upon subjects of interest to engineers, will always receive our very careful attention.

The little things are often most valuable, therefore, we especially solicit short articles on the small problems met with in daily practice. When illustrations are desirable a pencil sketch is sufficient.

Address all Communications and make all Checks, Money Orders and Drafts payable to

The Practical Engineer

46 North Twelfth Street Philadelphia, Pa.

SUBSCRIPTION RATES in the United States, Canada and Mexico, Fifty Cents the year, in advance.

FOREIGN SUBSCRIPTIONS to countries within the Postal Union, postage prepaid, One Dollar the year, in advance.

Entered at Philadelphia Post-office as Second-class Matter.

Ten Cents a Copy but only Fifty Cents a Year.

With this issue of "The Practical Engineer," the price for single copies is increased to ten cents, instead of five cents, as heretofore. This does not forecast an increase in the annual subscription price, which will remain at fifty cents a year. The increased price of single copies is necessary in order to give the newsdealers a living profit.

—o—

One Side of the Steam Turbine Problem.

A surprising feature in reference to the growth of the steam turbine has been the apparent indifference of the builders of reciprocating engines to contest in any way the extravagant claims made for the steam turbine by its builders and advocates. Whether this is due to the same feeling that causes a young man to look down on his kid brother, or, whether they think that by giving the turbine people all the rope they want, they will execute themselves, cannot be said, but the fact remains, that we hear constantly of turbine tests that have produced wonderful results, we are shown pictures illustrative of the decreased space necessary to install the two kinds of prime mover, etc., with hardly an argument in rebuttal.

There have been cases on steamships and on land where turbines have been taken out for one cause or another but nothing is heard about them. The wear on the turbine parts is claimed to be negligible by the friends of the turbine and if examples are shown of the wear on turbine buckets or other parts, they say that it is due to mismanagement or abuse.

These thoughts have been brought to mind by occurrences which took place at a recent meeting at the Franklin Institute, Philadelphia, where the steam turbine was discussed. The discussion was given publicity in the newspapers, sister societies were invited to be present, and the lecture hall was crowded by engineers and other men who were eager to learn more about this new factor in engineering.

The result was very disappointing from every point of view and as might have been expected, the representatives of two of the largest steam turbine builders held the floor the greater part of the evening in eulogizing the turbines manufactured by their companies and there was not one engine builder or reciprocating engine advocate present to dispute what were in many cases exaggerated statements.

One engineer did speak about some doubtful points, after the eulogizing process was over. The main portion of his remarks with the accompanying illustrations will be found in another column of this issue. It showed very clearly that wear does come upon turbine buckets and the question was asked: "What effect does the wear on the turbine buckets have on the efficiency of the turbine?" The reply of the turbine advocates to this was that the worn turbine buckets held up as examples, were the exception rather than the rule and even if they did wear as shown, the effect on the efficiency would be very small.

Out of all fairness to both types of engines, let us have discussions in which not only are the advantages of the steam turbine brought to the clearest focus but also the disadvantages. There has never been a machine built which has not had its comparative disadvantages and for that reason, if for no other, steam turbine advocates should not be afraid to have them brought forth, so that steam turbine users, after getting over their first ecstasies of delight, will not receive too great a shock when the questions of repairs and renewals are mentioned by the operating engineer.

—o—

Steam versus Electrically Driven Pumps.

Electrically driven feed pumps have frequently been recommended for use in a power plant where it is assumed that the steam consumption of the large unit per horse power is very much less than in the reciprocating pump, and while it is true that the average boiler feed pump consumes from 100 to 150 pounds of steam per horse power and the large generating unit only about one-fifth or one-sixth as much, there are other factors which enter into the practical application of each which has made the use of the steam driven pump almost universal.

Owing to the location of the steam pump being close to the boiler, the objection to them other than inefficiency usually does not apply as the boiler attendant has charge of them in connection with his other duties. For this reason, an electrically driven pump cannot be taken care of so well as a steam pump as the latter is more adapted to rough handling which they often receive.

The particular value of a steam driven pump, no matter how uneconomical, is the use of the exhaust steam for heating or drying purposes and when used in that connection, its inefficiency disappears unless, of course, more exhaust is given

out by the pump than is necessary for heating the boiler supply or for whatever purpose it is utilized.

The power required by a boiler feed pump is, however, small compared with the main engine and while its efficiency is very much less than in the large engine, the amount of steam consumed per hour is not so very great in pounds, and the saving would scarcely justify the substitution of the electrically driven pump with its additional first cost and complication.

One great practical disadvantage in having all the feed pumps electrically driven would be that when the main current failed in case of an accident or was shut down, storage batteries would have to be used to obtain power. This could or would be prevented by having a steam driven auxiliary in reserve.

Since it is the most common and economical method to use feed water heaters in connection with a steam engine plant, it does not make any difference whether the steam pump is uneconomical, as the loss of heat in the exhaust from the pump is absorbed by the boiler feed water which is returned to the boiler and therefore the heat is utilized.

The power actually necessary to pump a certain amount of water into the boiler is the same no matter what kind of a pump is used, and if there is a greater loss of heat in the one form than in the other, it is utilized in another way. For the reasons of less first cost, availability for boiler rooms and utilization of the exhaust, the steam pump is therefore almost universally used.

Education and the Engineer.

When it is considered that most of the advancement in steam engineering has taken place within the past twenty-five years, it is marvelous to think of the comparative growth in the number of engineers and the numerous responsibilities which they have had to meet during those times.

Twenty-five years ago, the engineer generally was a man who did little more than turn a throttle morning and evening, and when he was not breaking his back shovelling coal in the boiler room, he went around filling up his oil cups.

To-day, the chief engineer of a large plant must be almost a walking encyclopedia. He must be familiar with the different kinds of fuels available, the kind of feed water used, the proper methods of avoiding scale formation; he must be acquainted with different types of prime movers and dynamos, boiler feed pumps, feed-water heaters, heating systems, refrigerating machines, elevators, methods of illumination, and hundreds of other things equally as important.

The wonder of it all has been, where have the men sprung from to assume these arduous duties and how have they been able to cope with such responsibilities? It has invariably been by means of hard work and hard study that a successful engineer has pushed himself to the front. It is evident that no one can be acquainted with all of the subjects above-referred to, without having had to do a vast amount of studying, not to mention the continually keeping abreast of the times by understanding fully the advantages, or otherwise, of new apparatus which yearly is introduced in the engineering field.

Engineers in general do not appreciate the important factor which they play in the progress of civilization and they are too apt to hide their light under a bushel. It was recently stated at an engineers' meeting that while the hand that rocks the cradle might rule the world, it is the hand that holds the throttle that runs the world.

The public at large are beginning to realize this. President Roosevelt has said: "It is the men that do things" that have made this country the great country that it is, and if the engineers have not done things during this past quarter of a century, no body of men ever have.

The important part that an engineer plays in making the wheels of commerce hum is often forgotten and it is only when the electric lights go out, or the elevator refuses to run, or the water refuses to flow, that the thousands of people who depend upon him for their comfort begin to realize how important he is. This was recently illustrated when despatches were sent world-wide that the engineers at St. Petersburg refused to work, which meant that the city would be in darkness and, under the existing conditions, bloodshed and terror would reign. It was probably not until then that the Czar realized how much depended upon them.

All of this importance and responsibility have been due to hard work and constant study and the future demands, more than ever, that these things must be linked with a successful engineer's life.

About Your Subscription.

Don't fail to renew your subscription to "The Practical Engineer" when you receive notice of its expiration; otherwise your paper will be stopped. This is not because our methods are harsh but because when we do not hear from you, we must take it for granted that you do not wish to take the paper any more and that you therefore wish it discontinued.

Our lists are now so large that it is necessary to have a system in which all are treated alike and for the same reason the care of the lists must be left to those who are not as familiar with our old friends as the publisher is; so if you want the paper continued please don't fail to write us.

This announcement is made because our readers of long standing sometimes feel that we treat them somewhat harshly when we discontinue the paper, but all are treated alike and in this respect our system is the same as that used by all of the best modern periodicals. The old scheme of continuing the paper whether you want it or not and then sending a constable to collect, is not our way.

While we are discussing this matter of subscriptions we want to thank our engineer friends for the magnificent support that they have given us. No paper could well ask for more. Its circulation during the past year has increased constantly and rapidly and each month the increase has been greater. The edition for February was the largest ever published up to that time, yet it was entirely exhausted before the 20th of the month; and so it has been for a year past, nearly every edition being exhausted before the succeeding one was issued.

On second thought it seems almost superfluous to print this announcement because a very large percentage of our readers renew their subscriptions promptly but we want you all to continue to take "The Practical Engineer" so long as you continue to follow the profession, and we are going to make it so good that you will not want to miss a single issue.

STEAM BLOWER FLUE CLEANERS

By R. T. Strohm.

Perfect combustion in the furnace of a steam boiler is not yet fully reached in practical work. In fact, there are few boilers that are not smoke producers to a greater or less extent, and this smoke, passing through the tubes, deposits a portion of its soot on the heating surfaces, where it clings and accumulates. At the same time, the draft is of sufficient intensity to cause the hot gases to pick up and carry with them small solid particles of fuel, which are likewise deposited, either as

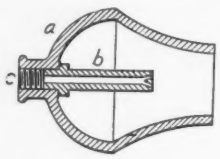


Fig. 1.

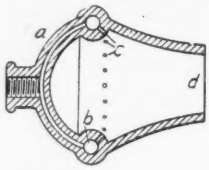


Fig. 2.

cinders, or as unburned coal dust, in the flues. The periodical removal of these accumulations of soot and cinder then becomes necessary, from an economical point of view.

The erosive and carrying effect of a rapidly moving current of gas offers a means of solving this problem of tube cleaning. It is well known that a jet of steam flowing into the atmosphere from a boiler carrying 100 pounds steam pressure will have a velocity of about 900 feet per second. At such a high velocity, the steam jet would induce a very rapid air current also in the same direction, the velocity of the combined air and steam current being, of course, less than that of the steam alone, but nevertheless quite high. Such a current, confined to longitudinal motion in a boiler flue, is capable of carrying with it a considerable amount of soot and cinder.

A form of blower cleaner operating on this principle is illustrated in Fig. 1. The head of the blower is a flared casting with a yoke *a* across one end, into which is screwed a short

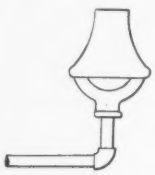


Fig. 3.

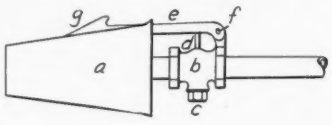


Fig. 4.

nozzle *b*, having a double opening at its free end. A piece of wrought-iron pipe is screwed into the fitting *c*, serving as a handle by which to manage the cleaner as well as affording a means of conducting the steam to the cleaner head. The head is inserted into a boiler tube at the front end of the boiler, and steam is turned on. The jets of steam, issuing from the end of the nozzle *b* at a high velocity, induce a flow of air into the tube, and the loose soot and cinder are blown through the tube into the back connection of the boiler.

Another form, employing the same principle as the foregoing, is illustrated in Fig. 2. In this one, the yoke *a* is cored out so as to form a steam passage leading to the chamber *b*, which extends entirely around the casting. From this chamber a number of small holes *c* lead to the inner opening through the casting. These holes are drilled so as to point toward the end *d* of the head. When steam is turned on, the rush of steam through a large number of small holes carries with it a larger amount of air than in the case of a double jet. The advantage to be gained, obviously, is the attainment of the desired end with a smaller consumption of steam. Like the preceding cleaner, this one is merely inserted into the front end of the tube to be cleaned. In case it is to be used for cleaning a vertical boiler with vertical tubes, it is attached to a handle as shown in Fig. 3.

In both of the cleaners thus far described, the steam supply is regulated by a valve in the pipe leading from the boiler, to which the steam hose is attached. Evidently, the steam escapes while the cleaner head is being shifted from one tube to another. To avoid this unnecessary waste of steam, an automatic cleaner head like that shown in Fig. 4 was made. In so far as its action is concerned, it is like that in Fig. 1. But,

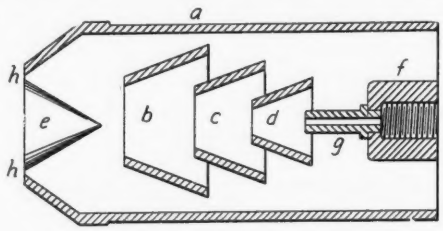


Fig. 5.

just in front of the head *a* is a valve *b*, which is held shut by the pressure of the steam as well as by a spring in the cap *c*. The stem *d* of the valve projects outward, and rests against a lever *e* pivoted at *f*. When the cleaner head *a* is pushed into the tube, the sloping shoe *g* strikes the wall of the tube, depressing the lever *e* and the stem *d*, opening the valve *b* and admitting steam. As soon as the head is withdrawn from the tube, the valve closes and shuts off the steam.

The previous types simply enter the end of the tube, and rely upon the blast to clean out the dirt. The form shown in Fig. 5 is different in a number of ways. In the first place, it is designed to be pushed into the tube, or from end to end if so desired, assuring uniform cleaning throughout the entire length. In the second place, it is made to use a minimum amount of steam with a maximum amount of air to perform its work. And, finally, it is so constructed as to direct the blast against the tube surfaces at a much more effective angle than the blowers which simply enter the tube end.

It consists of an outer cylindrical shell *a* cast in one piece together with the three truncated cones *b*, *c* and *d*, the cone *e*, and the yoke *f*. The latter are held central in the hollow cylinder by webs which do not appear in the illustration. The steam nozzle *g* is screwed into the yoke *f*, to which is also attached the pipe which serves as the handle in manipulating the cleaner and furnishing it with steam. The steam jet, blowing

through the truncated cones, induces air currents through each. But the smaller one *b*, by its air current, induces a greater one in *c*, and *c* a still greater one in *d*. So that, at the outlet of *d*, there is a larger volume of air and steam. This strikes the inverted cone *e*, and is divided, escaping from the cleaner head through the annular orifice *h*, *h*.

In the case of blowers which are not pushed through the tube, the velocity of the blast, and hence its efficiency, is some-

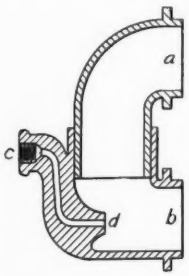


Fig. 6.

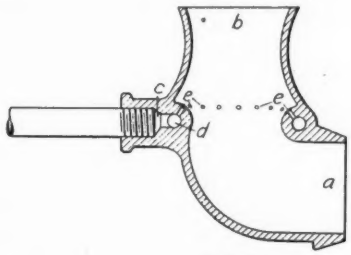


Fig. 7.

what diminished as it penetrates further into the tube, due to the frictional resistance along the dirty surfaces. With the type shown in Fig. 5, however, the blast, issuing from the annular opening at the base of the cone, may be directed with equal force against every portion of the internal surface, by simply pushing the cleaner along the tube.

The practice of using steam as the cleaning agent in blowers for the tubes of fire-tube boilers is avoided by some engineers, on the ground that the moisture in the steam makes the soot adhere more tenaciously to the tube. A form of blower intended to prevent any condensation of steam in the tube is illustrated in section in Fig. 6. It consists of two nozzles or elbows, the upper one *a*, sliding into the lower *b*, so as to be able to adjust the two nozzles to any convenient distance. Cast with the elbow *b* is a steam inlet *c*, leading to a small orifice *d* opening toward the open end of the lower elbow. The nozzle *b* is placed in the end of the tube to be cleaned, and the nozzle *a* in the end of one of the adjacent tubes, and steam is turned

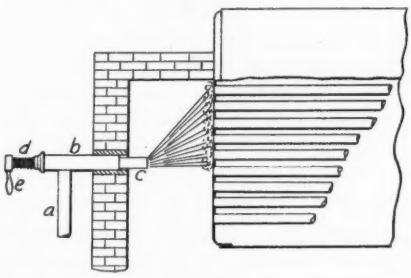


Fig. 8.

on through *c*. The jet issuing from *d* draws the hot gases from the tube containing the nozzle *a*, and forces them into the tube containing the nozzle *b*. These hot gases are considerably above the temperature of the steam, and so they are relied upon to prevent any condensation.

Another form of cleaner shown in section in Fig. 7, does not admit any steam at all to the interior of the tube. The tapered end *a* of the elbow is placed in the mouth of the tube, the flared end *b* pointing upward into the breeching or chimney. Steam, admitted through the opening at *c* into the chamber *d* which extends completely around the head, escapes at a high velocity through numerous small holes *e*, *e*, drawing the dirt from the tube and ejecting it into the chimney.

It may appear that the satisfactory cleaning of a tube by a mere blast of steam and gas is more than can be expected. To the writer it seems that the explanation of the good results obtained is not to be attributed to the gaseous currents alone, but likewise to the erosive effect of the soot and cinders moving at a high velocity, thus acting in the same manner as a sand blast, the erosive and cleaning effect of which is well known and widely used.

A form of blower tube cleaner recently placed on the market is shown in Fig. 8 as installed for cleaning the tubes of a return tubular boiler. The cleaner itself is permanently fixed in the rear wall of the setting. The steam pipe *a* conveys the steam to the sleeve *b* containing the nozzle *c*, forcing the latter inward against the counterpressure of the spring *d* which is fastened to the stem of the nozzle section. The nozzle tip is so constructed as to spray the steam jet so as to cover a large area, as indicated. The handle *e* is then turned through a complete revolution, thus turning the nozzle, and directing the steam blast into all of the tubes. The advantages claimed by having this arrangement are numerous. In the first place, the time of cleaning is greatly lessened by reason of the large number of tubes covered by the blast. Again, the steam jet acts in the same direction as the natural current of the gases, and therefore does not impede the draft. Finally, there is no opening of the smoke box, and consequently the cleaning may be done without shutting down the boiler even partially, and without interfering with the draft, or the regular operation of the boiler.

Water Softening.

Softening water for every industrial purpose, by means of lime and soda ash, has now reached the stage where any introduction to the subject is almost superfluous.

The chemical process of softening water by lime and soda ash has been an exact science for many years but in order to make use of this knowledge commercially in the treatment of water, for industrial purposes, it was necessary to perfect a mechanical device that would always add the correct proportion of the chemicals to a specified amount of water continuously and automatically.

In order to meet these requirements, the American Water Softener Co., of Philadelphia, sent an expert engineer to Europe to thoroughly investigate the various water softening systems that are in universal use there. These investigations were made on all the machines working under every practical condition, and after the most careful consideration it was proved beyond a reasonable doubt that the Bruum-Lowener System was superior on all points. The American Water Softener Co. immediately acquired the United States rights and patents for this system and have for the last three years been carrying on a constantly increasing business, installing plants all over this country that treat various quantities of water, as well as various qualities, continuously and automatically.

These plants have been installed in apartment houses, ice plants, paper mills, silk mills, starch works, glue factories, and other kinds of manufacturing plants, as well as on many railroads.

LETTERS FROM ENGINEERS

IN ORDER to make this department of THE PRACTICAL ENGINEER as interesting as possible, a moderate rate will be paid by us for all contributions published under this heading. However, we do not assume responsibility for the ideas or opinions expressed. None need hesitate to contribute because of inability to draw or write well. We will redraw or revise whenever necessary—it is the idea we want. New ways of doing old things, criticisms of accepted theories, and general engine-room experiences are especially solicited.

Troubles with Governors on Fire Pumps. Remedy.

EDITOR THE PRACTICAL ENGINEER:

Some time ago I was called into a large manufacturing plant to see if I could remedy a bit of trouble the engineer was having with the governors on two large fire pumps that had just been installed. After a careful examination of the entire piping arrangement connected from the main discharge line to the governors and after making a thorough examination of each governor, such as examining the stem for alignment, the leather cup for its fit, and making sure it was free from grit, I also tested each spring to see that it would compress properly and show the proper tension. I then looked after the stem packing to make sure that the valve would act readily the moment the water pressure would be raised or lowered.

I found every feature above-mentioned in first-class condition, but when the two pump governors were cut in together they would not work; that is, but one of them would regulate. The other would shut down entirely and allow no steam to enter the cylinders whatever. I thought perhaps it was due to a weak spring on the governor that failed to operate, so I took the spring off the other governor and placed it in the one that would not work, but to no avail, as the same thing happened again. Then I began to study out a remedy and I came to the conclusion that the only way out of the trouble was to connect them up separately to the discharge line, after which I found they worked all right.

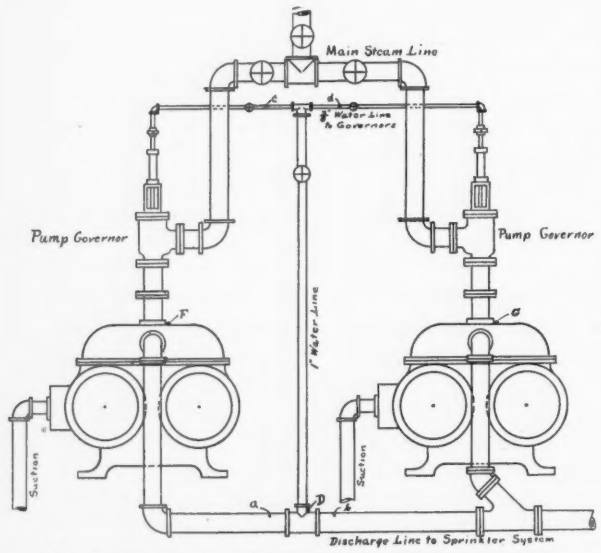


Fig. 1.—Water Connections to Governors which gave trouble.

The accompanying sketch, Fig. 1, shows how the governors were originally connected up, the 1-inch water line being connected to the discharge line at the joint D. In making the change, I drilled and tapped a ½-inch hole at *a* and *b* in the discharge line and then by cutting the ⅜-inch line at *c* and *d*, I made up the connections with proper fittings, taking out the 1-inch line entirely after the connections were made from *a* to *c* and *b* to *d*. The new arrangement is shown in Fig. 2, and the governors worked very satisfactorily. The sketches represent the water end of the pumps, the flange joints at F and G are on the steam end of the pump.

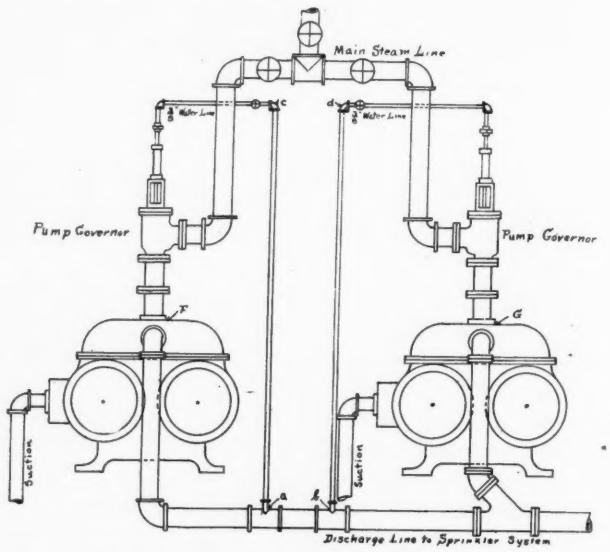


Fig. 2 —Water Connections to Governors which worked satisfactorily

Depew, N. Y. N. W. A.

Readings on Switchboard. Starting Alternating Current Generators.

EDITOR THE PRACTICAL ENGINEER:

Among the questions and answers of the December number I note the inquiry of F. C., Toronto, Can., regarding the starting of alternators, etc., and also your invitation for further suggestions. Regarding the indications of the ammeter and voltmeter, the ammeter was connected directly in the alternator circuit and read the output of the generator, as you said, but this reading was at the primary electro-motive force which in this case was very probably about 2300 volts at full load. Thus the current of 25 amperes represented an output of about 57,500 watts, which at the basis of your figures of 57 watts per lamp would supply approximately 1000-16 candle power lamps, instead of 50, or 2000-8 candle power lamps instead of 100, which would be a fair load for the 75 horse power engine. The voltmeter was connected to the secondary circuit of a potential transformer and indicated the secondary voltage as it is unusual in small plants especially, to use a voltmeter indicating the full electro-motive force of the primary circuit.

Regarding the course of procedure in starting an alternator, do you not consider it better practice, when but the one generator is used on the circuit, to build up the voltage with the

external circuit closed? This allows the load to build up gradually with the voltage which is much easier on the machine and engine, especially where nearly the full external load is on the circuit at starting, as the engine, belting, etc., would be subjected to rather severe strains by closing the main circuit on full load at full voltage.

Lake City, Minn. W. E. L.

Opening and Closing Valves. A. T. Answers all His Critics.

EDITOR THE PRACTICAL ENGINEER:

When any person claims that there has not been evidence enough to convince him that the wrench habit is wrong, he must be either hard to make understand or else he does not understand the question he is trying to argue.

I have failed to see in print where any of those so-called expert engineers, who are defending the wrench habit, give any excuse or any good reason for using the wrench. They have been unable to say why a valve that is in good condition needs the use of the wrench or to offer any evidence to show that it is in any way required. They simply say they use it. And why do they use it? One offers the slim excuse that he lost some skin on a hot valve wheel. Is this any real cause for it?

Another writer claims that the insurance company would not allow the steam turned off the main and he would have to use a wrench to make the valve tight. This is another lame excuse, because no insurance company will prohibit any one from making any repairs that are necessary. I have only recently spoken to two inspectors from fire insurance companies and they said they never prevented anyone from keeping the valves or any other part of fire service in repair.

Is there, then, any evidence so far to prove that it is proper to use a wrench? If there is, I fail to see it. Mr. Wakeman says he has just renewed some discs and found one of them split. He says no wrench was used on those valves. I have always found that if a disc fit too snugly on the inside of disc holder, it would cause this split. What good would a wrench do on a valve with such a disc? Would it be of any use? No. All the pulling that Mr. Wakeman or anyone else could do would not stop it from leaking.

I would like to say a few words to "Broken Valve Stem." I do not lay claim to being a globe trotter but I have been employed in enough places throughout the United States during my 20 years' experience and I am perfectly satisfied with the amount of surface I have strayed over. In regard to "elbow grease," very little is used in my plant, let it be a model plant or not, but some good sense and sound judgment are used in caring for the valves of my plant. They all close and are steam and water tight at 65 pounds water pressure or 100 pounds steam pressure. I do not advocate pulling with all the strength that can be mustered up to close a valve any more than I do using a wrench, for a valve can suffer in various ways if handled with ignorance.

No. Abington, Mass. A. T.

Opening and Closing Valves. Never saw any Difference when Wrench was Used.

EDITOR THE PRACTICAL ENGINEER:

I have been very much interested in the articles on "Opening and Closing Valves" and have given the matter much thought.

I have been in the engineering profession fifteen years, thirteen of which I served on board ship and two years at stationary work. I have been second with chief engineers who would discharge any one they saw using a wrench on a valve and I have been with men who would use a wrench themselves. I have had a chance to see the difference, if there was any, and I must say that I never saw any difference when a wrench was used. For myself, I will use a wrench when it is necessary and if the wrench is used with judgment it will not injure the valve. The engineer is a man who must have judgment and if he will use it in regard to this question, he will not do any damage.

St. Paul, Minn. R. F. I.

Opening and Closing Valves. New Valves do not Need Wrenches to Make Them Tight.

EDITOR THE PRACTICAL ENGINEER:

Kindly allow me to say a few more words in regard to "Opening and Closing Valves." I feel as though I have got to say a few words to convince the writer that signs himself "A Broken Valve Stem" that new valves do not need wrenches to make them tight. He says: "For if I put on a new 10-inch valve to-day, I would train it to the monkey wrench."

Now, that is where it seems to be impracticable to use a wrench, because the manufacturer places a wheel on the valve stem large enough to ordinarily shut their valves steam tight; it is uncalled-for pressure on the valve stem; and there is no sense in using a wrench until a valve cannot possibly be closed tight by hand.

Suppose a piece of scale gets on a globe valve seat, it would be impossible to close it steam tight. Now, the question is, would a monkey wrench close it steam tight? No, of course it would not. All the power that a man could apply would not close it tight; it would twist the stem off first. Therefore I say to "Broken Valve Stem," use common sense and not a wrench. Because "elbow grease" was made before wrenches is no reason why we should discard it and use a wrench because it is easier to twist a stem off with a wrench than without one.

As I have never had one single chance to use a wrench on a valve, I think there is seldom a time when one is needed.

Shirley, Mass. H. N. B.

Rodney's Troubles.
Or Do We Need a License Law in Michigan?
(Seventeenth Letter.)

Deer mister editur, that cheef injinear at thu villidge power hous iz alwase trien tu git me mixd up in a argumint ov sum kind. yestaday he wus standin neer mi thrasher injine az i wuz doin sum wurk fur mi dad and he askd me if i evur usd enny saginaw packen fur tu maik gaskets with. now pleeze tel me whut kind ov packen that iz. i told thu cheef that ide usd a lot ov it but tu tel the truth i nevvur seen enny ov it. yestaday mornen az i wuz starten mi injine thare wuz sum watter got intu the silindur and thu rubbur blode out frum thu bak hed joint. i didnt hev enny rubber handy fur tu maik a joint with so i lusened up thu burrs what hold the hed on and whare thu leek wuz, i druv in sum peeces ov pine that i whiteld tu fit thu plase and it didnt leek enny more. now dont u think

its a gud thing tu no how to fix up a injine when its broak lik that.

anuther thing i wud lik tu no, mistur editur. iz thare 2 kinds ov sodder? thu cheef at thu lite stashun told henry that when i got mi steem gaig soddered that ide sune hav tu git it fixd agin fur the commin sodder wud not hold it. now i think the cheef iz rong fur the tinnur didnt uze the commun sodder he uzed sum kind ov yeller stuf that lukd lik bras ground up, fine lik sand, and he sed he braized it or sumthin lik that enny how its holden yit and its most o yeer sinct i had it fixt. sum tims i think them lektrik lite fellers dont no aul thare p's and q's about the steem injine, or lecktrisitee ether, fur when the power hous cheef wuz takken to henry a fu daze ago he told him that german silvur iz a bettur konducktur than copper. now i alwaze thot that a konduektur wuz a fellar whut taiks up the tikets on a rale rode trane, or the 1 that taiks ure fair on the streat kar and hollers out the streat u want tu git off at in a big sitty lik whare u liv in.

u nevvur told me how u likd the rute beggars, mebby u didnt git em, or mebby thay hed a slite tutch of the sun and wuz a bit bittur when they wuz kukd, if thay aint rite let me no and ile send u sum that are gud.

ures trooly
rodney gumkirk
orkners korners mishegan
munrow kounty

———o———

Rule for Calculating the Number of Teeth for Change Gears.

EDITOR THE PRACTICAL ENGINEER:

In the October number of "The Practical Engineer," J. P., of Middletown, Ohio, asks for a rule for calculating the change gears to use for cutting threads not marked on the index of his lathe. I have found the following rules a great help to me in cases of that kind:

1st. To find the proper gears to use when not necessary to compound the gears as in Fig. 1:

Multiply the threads per inch on the lead screw by some number that will give as a result, the teeth on some gear convenient to use on the spindle. Then multiply the threads to be cut by the same number and the result will be the gear to be used on the lead screw.

For example, my lathe has a lead screw with 10 threads per inch and suppose I want to cut 28 threads per inch; then, if I multiply by some number, say 2, 10 (threads per inch on lead screw) $\times$ 2 = 20 teeth in gear to use on spindle, and 28 (threads to be cut) $\times$ 2 = 56 teeth in gear to use on lead screw.

2nd. In cases where the required threads cannot be cut by gears as arranged in Fig. 1, it is necessary to compound the gears as shown in Fig. 2. The rule for compound gears is as follows:

Select some gear convenient to use on the spindle and multiply the number of teeth in it by the threads to be cut, calling the result *A*.

Select some other gear convenient to use on the lead screw and multiply the teeth in it by the threads per inch of the lead screw, calling the result *B*.

Then select two gears of unequal sizes such that the result *A* multiplied by one of them will equal result *B* multiplied by the other one of them and use these two gears on the idler stud in such a position that gear multiplied by result *B* is in position of second wheel, Fig. 2, and gear used to multiply result *A* is in 3rd position.

For example, it is required to cut 30 threads per inch with compound gears on a lathe with 10 threads per inch lead screw. Select a gear with say 24 teeth to use on the spindle, then 24 $\times$ 30 = 720, which is result *A*. Next select a gear with say 36 teeth to use on lead screw, then 36 $\times$ 10 = 360, which is result *B*.

Result $A \times 44 = 31680$.

Result $B \times 88 = 31680$.

Therefore, use gear with 88 teeth in position of second wheel, Fig. 2, and gear with 44 teeth in position of third wheel, Fig. 2.

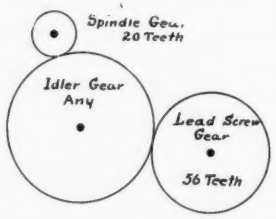


Fig. 1.

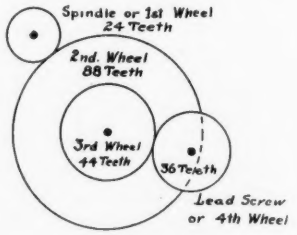


Fig. 2.

Several other combinations will give the same result.

The result may be proved by the following formula:

Threads to be cut
= thrds. on lead screw $\times$ gear on lead screw $\times$ teeth 2nd wheel
teeth on 3rd wheel $\times$ teeth on spindle gear

That is, in the above example:

$$\frac{10 \times 36 \times 88}{44 \times 24} = 30 \text{ threads per inch to be cut.}$$

I wanted to cut 11½ threads per inch on my lathe with lead screw 10 threads per inch. It was not shown on the index plate, so I selected gears with 40 teeth for spindle and 56 teeth for lead screw and by applying the rule, I found that by putting on the stud a gear of 36 teeth in second position and a gear of 44 teeth in 3rd position, I obtained a result almost but not absolutely correct. The rule worked out as follows:

$40 \times 11\frac{1}{2} = 460$, result *A*
$56 \times 10 = 560$, result *B*
$560 \times 36 = 20160$
$460 \times 14 = 20240$

so I used a gear with 36 teeth in 2nd position and one with 44 teeth in 3rd position. Proved by the above formula we have:

$$\frac{10 \times 56 \times 36}{44 \times 40} = 11.45 \text{ threads per inch}$$

which is near enough for all purposes.

Montreal, Canada. F. A. L.

———o———

Area of Chimney.

To compute the required area of chimney for any boiler, multiply the nominal horse power of the boiler by 112 and divide the product by the square root of the height of the chimney in feet. The quotient will be the required area of the chimney in square inches. For stationary boilers, the area of the chimney should be one-fifth greater than the combined area of all the flues and tubes. For marine boilers, the general rule is to allow 14 square inches of chimney for each nominal horse power.

HIS MASTERS VOICE.

AN ORDER TO HIS ENGINEER.

This is Mr. Rhodes' contribution to the controversy on "Opening and Closing Valves."

QUESTIONS and ANSWERS

THE editor will be glad to receive from the readers of THE PRACTICAL ENGINEER, such questions relating to engineering subjects, as may, from time to time, occur to them. All questions and answers should be addressed to the editor and accompanied by the name and address of the writer, which will not be published, however, unless especially desired. It is the intention that questions shall be answered by the readers, and even though the editor may, from time to time, publish answers and questions, he especially desires the readers in such cases to contribute any further information, in connection with the points raised, that they may consider of interest. All questions and answers received by the editor will be published, as far as practicable, but he reserves the right of editing or rejecting any communication.

Amount of Exhaust Steam Necessary to Heat a Building.

EDITOR THE PRACTICAL ENGINEER:

Will you kindly advise me if the amount of horse power required to heat a building when heated by exhaust steam can be determined in any other manner than by weighing the condensation? Your answer to F. H. R. in the December issue suggested the question. Could it be determined from a card taken with a given load with and without the back pressure on engine? I thank you in advance for any information you may afford.

Chicago, Ill. F. W. McC.

The horse power required to heat a building can be obtained by several methods other than by weighing the water of condensation but they are all closely related to the finding of the amount of water or steam the system uses per hour. It cannot be determined directly from the indicator card without the aid of the steam tables and except that the density and temperature of the steam are affected by the back pressure, it is not of any special value, because after the point of cut-off, there is a certain amount of steam in the cylinder of the engine, the total heat of which depends upon the pressure and its corresponding temperature.

The important things that must be known are the amount of steam that the engine uses per minute or per hour and the temperature of the steam at exhaust. The horse power of the engine does not affect this total amount directly because some engines are vastly more economical than others.

The method of procedure of finding the amount of heat that an engine is giving out would be as follows: Find the amount of back pressure by measuring on the indicator card from the atmospheric line, from which the temperature can be obtained in the steam tables. As the temperature of the room in which radiators are placed is generally assumed to be 70 degrees, find the difference between the temperature of the exhaust steam and 70 degrees. The heat per minute given off from 100 square feet of radiating surface in British Thermal Units is equal to three times the difference. This is based upon the fact that one square foot of radiating surface is capable of giving off 270 heat units per hour per degree difference in temperature. The total heat of the steam being known per pound and the number of cubic feet of steam in one pound at the pressure of the exhaust being obtained, the number of cubic feet of steam required each minute to supply 100 feet of radiating surface with the air 70 degrees can be calculated.

The following table is based upon these calculations and the steam consumption of different types of engines:

Steam press. above atmos.	0	1	2	3	10
Temperature of steam	212	216	219	222	239
Temperature of air	70	70	70	70	70
Difference	142	146	149	152	169
Heat per minute from 100 sq. ft. radiation	426	438	447	456	507
Total heat of stm. above 212	966	967	967	967	973
Latent heat of steam	966	963	960	957	946
Cu. ft. of steam in 1 pound	26.4	24.6	23.3	21.0	16.2
Cu. ft. of steam required each minute to supply 100 feet radiating surface	11.6	11.2	10.8	10.1	8.8
Radiating surface supplied per horse power: Throttling eng.	152	146	143	139	126
Automatic eng.	134	129	127	122	112
Corliss eng.	114	110	107	104	95
Comp. eng.	95	91	90	87	79

From the above table, it will be seen that a 100 horse power throttling engine with a back pressure of 2 pounds will be capable of heating 14,300 square feet of heating surface; an automatic cut-off engine, 12,700; a Corliss engine, 10,700; and a compound non-condensing, 9000 square feet under the same conditions.—[Ed.]

Dynamo Voltage. Is Resistance in Armature Circuit of a Motor Dangerous?

EDITOR THE PRACTICAL ENGINEER:

Kindly answer a couple of questions through your valuable paper:

(1). I am in charge of a 35 kilowatt continuous current machine which operates three electric elevators and three electric motors and lights a six story wholesale house. When starting the machine in the morning, we have no trouble to raise 225 volts, but I carry only 220 volts; after shutting down at noon hour, I cannot get over 215 volts and sometimes less. What is the reason for this?

(2). I have one 220-volt motor of 3 horse power, supplying power for a buffing machine, and the man using it claims it runs too fast. As the pulley on the motor cannot be made smaller and the one on the machine cannot be made larger, I adjust the speed by having the lever on rheostat on second bar. Is there any danger by so doing? I have been told by a prominent engineer that there was.

Toronto, Can. F. C. E.

(1). There may be several reasons why the dynamo fails to attain its maximum voltage after starting up. The electromotive force of a dynamo is proportional to the strength of the field, the number of conductors on the armature and the speed of the armature. Of these three quantities, the only one that exercises any influence on the voltage, if the speed of the dynamo remains the same, is the strength of the field, as the number of conductors on the armature, of course, remains the same. The strength of the field is dependent upon two quantities, the number of turns of wire on the poles and the current passing through them. If the machine is of the shunt type, the only thing that will influence the field strength is the resistance of the field circuit and hence the current flowing through it.

Assuming therefore that the machine is a shunt one and

everything is running under the same condition after starting as it was before, the only thing that can affect the voltage is the current in the shunt field. This may be reduced by the fact that when the field coils get fully heated up their resistance is increased and it may be that allowing the dynamo to stand during noon hour brings the heat more to the surface and hence increases the field resistance about the time the machine is started up. This can best be found out by applying a sensitive thermometer to the field coils.

If the dynamo is compound wound, it may or may not be overcompounded. If the dynamo is overcompounded and started up without any load, its voltage will not be so high as when the load is thrown on. This is evidently not the case, however, since the machine starts up all right in the morning. In all of these cases, it is assumed that the resistance in the field circuit is all cut out.

There are some practical reasons why the voltage may not be so high after starting at noon hour. One of these might be caused by the accumulation of carbon dust or oil on the commutator. This black coating will often allow current to pass through it while hot and soft but after the machine has stood awhile and the commutator becomes cool, the coating might become harder and of higher resistance and by making an inferior contact between it and the brushes, cause less current to pass through them. Close inspection might reveal some other reason.

(2). The chief objection to running the motor mentioned with resistance in the armature circuit is its decreased efficiency. If the resistance coils in the rheostat are of sufficient capacity to carry the current passing through them, there can be no danger.—[Ed.]

Steam Pressure when Blowing Water out of Boilers.

EDITOR THE PRACTICAL ENGINEER:

I am firing a boiler which carries 70 pounds of steam. I have had several scraps with my employer about blowing off the boiler. He says that I should have 60 pounds of steam on when blowing off and I claim that 15 pounds of steam is enough. I had charge of 12 locomotives on the Fitchburg Railroad for a year and never blew one off with more than 20 pounds pressure. If I am wrong I will go and sit down in the shade.

Troy, N. Y. J. R. H.

You are right. It is best that the steam pressure should not exceed 10 or 15 pounds when blowing the water out.—[Ed.]

Solution for a Bichromate Battery.

EDITOR THE PRACTICAL ENGINEER:

Will you kindly answer the following question through the Question and Answer column of your valuable paper?

What should be the density of the electrolyte of a bichromate or Fuller cell when gauged by a hydrometer? If no hydrometer is at hand, what are the correct proportions of awter and acid?

Paterson, N. J. I. S. C.

The elements of this cell are zinc and carbon. The zinc plate is placed in the bottom of a porous cup inside a glass jar; the carbon plate is placed on the outside. About two ounces of mercury are placed in the porous cup with the zinc for amalgamation and the cup is filled with dilute sulphuric acid.

The outside jar is filled with the electrolyte which consists of three parts of bichromate of potash, one part sulphuric acid and nine parts of water in which the carbon plate is immersed. The electrolyte is originally an orange color. When this becomes bluish in tint add more crystals of bichromate. Should the color be normal and the cell show a weak electro-motive force, add fresh sulphuric acid.—[Ed.]

Valve Gear Problem.

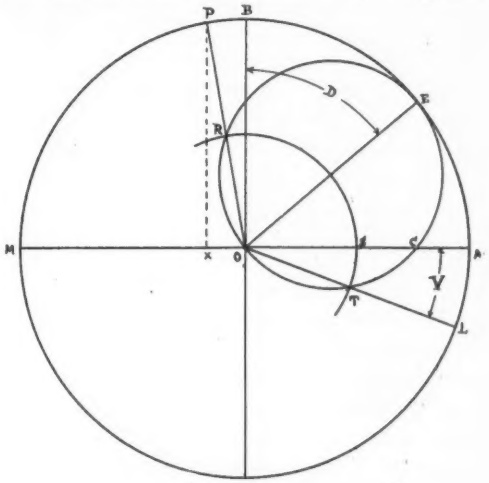
EDITOR THE PRACTICAL ENGINEER:

Please give rule for finding lap and lead when the valve travel, angle of advance and cut-off are given.

Holmesville, Ohio. A. O.

Perhaps one of the easiest methods of finding the lap and lead when the valve travel, angle of advance and cut-off are given is by means of the Zeuner diagram shown in the accompanying sketch, which is constructed as follows:

Since the valve travel is known, describe a circle with the radius OA equal to one-half the valve travel, and draw its vertical and horizontal diameters. The angle of advance being given, lay off the angle BOE, marked D, equal to it. Then OE will represent the position occupied by a line joining the centre of the eccentric with the centre of the crank shaft. On the line OE as a diameter, describe a circle. Then any chord drawn from O to the circumference of the circle will represent the space travelled by the valve when the crank is in that position; for instance, when the crank would be on its dead centre as represented by line OA, then the distance OC will represent the amount the valve has moved from its central position.



Valve Gear Problem

The cut-off being given, lay off on the line AM from A, the proportion of the stroke that cut-off is to take place, as at X; draw PX perpendicular to AM and draw PO. PO represents the position of the crank at cut-off and the distance OR represents the steam lap. With OR as a radius and O as a centre, draw the steam lap circle which crosses OA at S and the eccentric circle at T. SC represents the amount the port should be open at the beginning of the stroke and hence is the amount of lead, and the angle AOL marked V is the angle of lead. Therefore by measuring OR and SC, the amount of lap and lead can be easily obtained.—[Ed.]

The Swan Steam Engine Piston and Packing.

One of the chief difficulties encountered with engines, especially after they have been in use for some time, is the wearing out of round of the cylinder. This is particularly true of horizontal engines where the weight of the piston comes upon the bottom elements of the cylinder. The effect of this wearing out of round has cost many thousands of dollars in reboring, bushing and renewing cylinders, not to mention the cost of delays necessary to make such changes and the leakage of steam past the piston, which goes on usually without discovery, as the effect of leakage past the piston is very seldom, if ever, detected by the indicator. The way it is usually discovered is in the size of the coal bills.

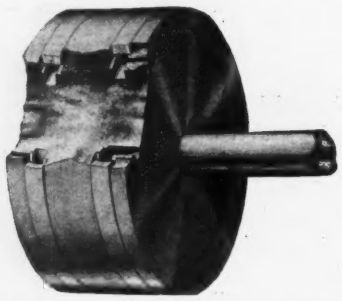


Fig. 1.—Exterior View of Swan Piston and Packing

To overcome this difficulty, which is inherent in all horizontal engines, Mr. James Swan, of Seymour, Connecticut, has recently invented a steam engine piston and packing which can be adapted to all kinds of cylinders, old or new, and whether the surface is even or uneven, it will fit the cylinder tightly with as little friction as possible.

The arrangement for preventing leakage, and, at the same time, requiring a minimum amount of friction is shown in the accompanying illustrations. It consists of a piston made as light as possible by coring and two snap-rings of special design. The ends of piston have a number of small holes bored in them so as to admit steam pressure, not only under the piston rings, and thus expand them outward against the walls of the cylinder, but also, so that the steam pressure will strike the side of the rings and by its pressure maintain a perfectly tight steam joint on the exhaust side of the piston.

The accompanying illustration, Fig. 1, represents an exterior view of the piston and packing and Fig. 2 represents the end view and section across the centre of the piston. In Fig. 2, A, represents the circumferential grooves which run around the periphery of the piston, and into which the cast-iron snap-rings D fit. The grooves are provided with shoulders upon which the ring rests when in their normal position. They are cut deeper than the piston rings to allow steam to enter under the rings when there is pressure in the cylinder. Each end of the piston is provided with a number of openings, as at B and C. The openings B lead into the grooves, so that the pressure of steam bearing against the piston ring will keep them steam tight, and the openings C lead into the grooves A and maintain a positive pressure under the rings proportional to the pressure in the cylinder.

The operation is as follows: Suppose in Fig. 2, the piston is moving toward the right. The steam pressure is then acting on the head end of the piston and the steam will enter the openings B and C on that side, and, acting under the inner periphery of ring D, expands it outwards, causing it to engage the walls of the cylinder closely. Leakage from the annular opening under D is prevented by the steam pressure acting through holes B by keeping it tight against the exhaust side of the piston. The action of the steam upon the rings is, of course, the same whether the steam is working under boiler pressure or expansively. During this movement of the piston towards the right, the ring on the right end remains in its normal, or contracted, position, and out of frictional engagement with the cylinder, as the cylinder is exhausting on that side of the piston.

As soon as the stroke towards the right is finished and the exhaust commences, the pressure upon the inner periphery of the left ring is relieved and the ring contracts to its normal position, and as soon as admission or compression begins at the right end of the cylinder the steam passes through openings B and C on the right end of the cylinder, expanding the ring D on that end outward and keeping it steam tight as before. The rings on each end of the piston thus act alternately and the action is the same when the piston is moving in either direction, the outer periphery of one ring only being in contact with the cylinder, the body of the piston and the other ring moving within the cylinder freely.

As the piston ring which is operative is expanded by internal pressure, it will conform within reasonable limits to irregularities in the wall of the cylinder, and, if applied to an old and worn cylinder, will stop the leakage of steam past the piston and hence greatly increase the efficiency of the engine and reduce the cost of the coal pile.

These pistons have been used successfully on all kinds of engines of both the high and low speed types. Engines with

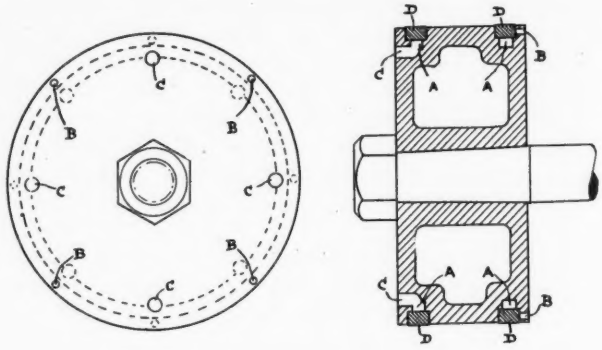


Fig. 2.—End View and Cross Section through Piston

as high a speed as 475 revolutions per minute have been equipped with them, and the results have shown that they save steam by preventing leakage. One of these pistons has been placed on a 12 x 12 engine running at 250 revolutions per minute, at Haddon Hall, Atlantic City, N. J., and the chief engineer reports a saving in the friction horse power as well as in the consumption of steam. The manufacturers are the James Swan Patent Steam Piston Packing Co., George P. Rogers, General Agent, 305 Bartlett Building, Atlantic City, N. J.

The Ashton Inspector's Testing and Proving Outfit.

The accompanying illustration represents an inspector's testing and proving outfit which has been designed to meet the requirements of boiler and power plant inspectors, mechanical and chief engineers. It is made with the idea that it can be portable and at the same time be durable and accurate. The

Ashton Inspector's Testing and Proving Outfit

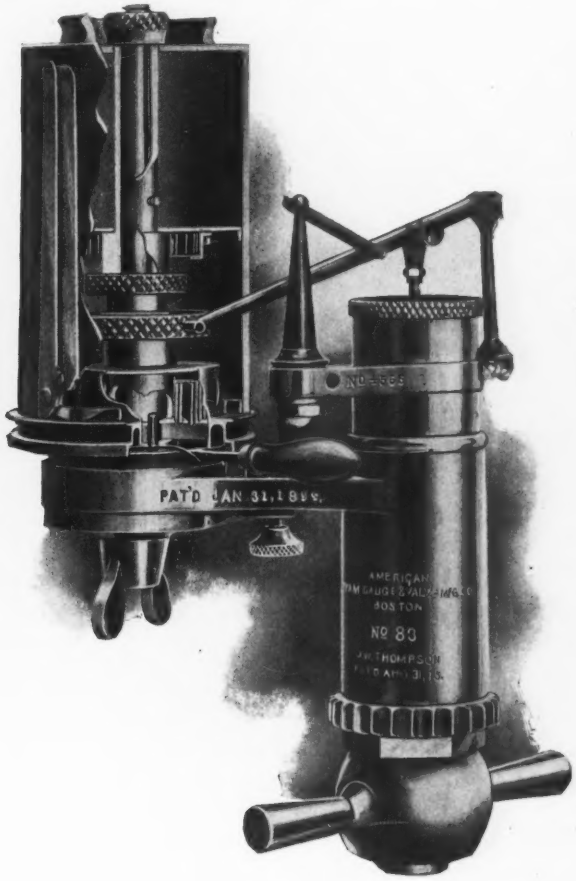
outfit consists of a 3-inch standard test gauge, screw test pump, gauge hand puller, hand set, lever handle union gauge cock and screw driver. All of these instruments are nickel plated and are packed in a velvet lined leather case fitted with lock and handle. The approximate weight of the outfit is 8 pounds. The Ashton Valve Company, of 271 Franklin Street, Boston, Mass., are the manufacturers.

An Improved Detent Motion. A Valuable Addition to the Indicator.

When taking indicator cards from high speed engines, there is nothing that usually troubles the engineer so much as the taking off of a card and the putting on a new one. This simple operation is often attended with vexatious results, since when the drum is stopped, the indicator string flops around in a loose fashion which often causes it to break and when the barrel of the indicator is released, if the string is not tight, the spring in the barrel will tighten the string with such a shock as to often produce disagreeable results. The general result of this is that, the operator of the indicator often finds it more handy to disconnect the string altogether from the reducing motion and run chances of catching the rapidly moving point of attachment when ready to take another card.

This trouble is wholly obviated by the use of a detent motion as applied to the new American Thompson Indicator, manufactured by the American Gauge and Valve Mfg. Co., of Boston, Mass. With this arrangement after the drum carriage is once connected with the reducing motion, it need not be disconnected until desired, as means are provided for stopping the drum without making any change in the connection with the pantograph or reducing device.

The accompanying illustration shows one of these indicators fitted with the detent motion. When it is desired to stop the drum, the handle, shown extending from the barrel, is moved to the left allowing the drum under the action of a spring to rotate to its extreme position where it remains until put into action again. After the old card has been taken off and a new one adjusted, the drum is put into synchronism with the reducing motion again by simply turning the milled rim at the top of the indicator which brings a catch in line with it and the indicator starts revolving smoothly and without shock.



An Improved Detent Motion

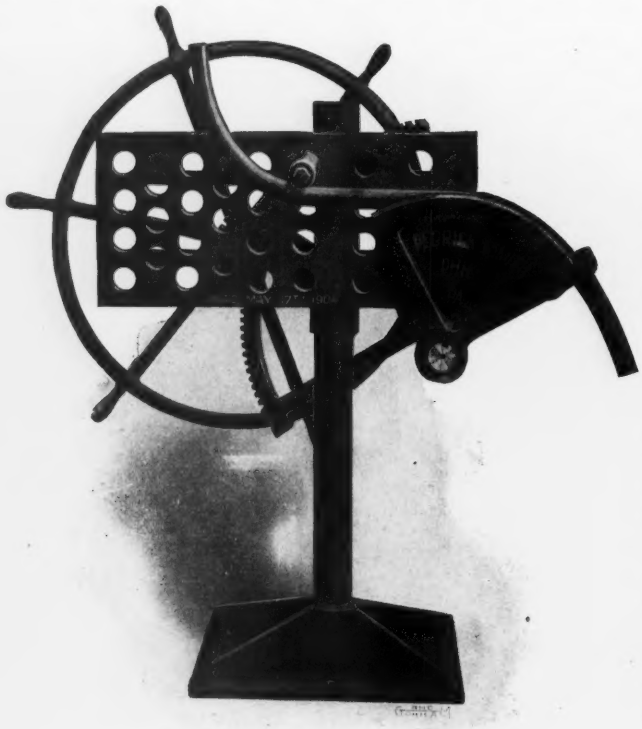
This valuable property not only should appeal to those indicating high speed engines but to those who must indicate locomotive and marine engines where all kinds of expedients have heretofore been resorted to to obtain this end.

Pedrick & Smith Pipe Bending Machine.

The accompanying illustration represents a pipe bending machine which has been recently patented and which was designed to meet the demand for a portable machine which can be easily manipulated and which will perform its work in short time.

It is of simple construction, light in weight and can be carried about wherever the work is to be performed. It can be secured to any column, stanchion or available support or a suitable stand is furnished, as shown.

The machine is operated by a hand wheel which carries a pinion; the latter engaging a quadrant gear operates the bending quadrant. One end of the pipe is held in position by a U-shaped clip while a pin or roller in the platen engages the other end. The placing of the pin or roller governs the curvature obtained.



Pedrick & Smith Pipe Bending Machine

Piping of steel, iron, brass, copper or other material can be bent cold up to 2 inches in diameter, with one man. One man can bend a piece of 2-inch pipe to an S-bend in three minutes, no other assistance or device being used or needed. When pipes are coated, galvanized or tinned, this machine will bend such pipe to any desired shape without breaking the coating in any way.

It is being used extensively in shipyards, pipe shops, locomotive works, sugar houses and power plants where pipe is used to any extent, and by erectors of heating plants, structural and architectural iron workers, and fire escape manufacturers are finding this machine useful as it is adapted for bending light angles, flat or tee bars to any desired radius by the use of special dies which can be attached.

Any further information can be had by addressing Pedrick & Smith, 226 E. Girard Avenue, Philadelphia.

Crane Renewable Seat and Disc Valves.

Fifty years' practical experience in the manufacture of steam and engineering appliances of all kinds and the degree of perfection which has attended all their efforts in developing and placing at the disposal of their numerous patrons many articles of recognized merit, have established for Crane Co. a reputation, the enjoyment of which they may be justly proud.

The home office and works of this well-known company are located in Chicago, with representative branch houses in every principal city.

They have recently brought out and have applied for patents on improved renewable seat and disc globe and angle valves.

These valves are suitable for working pressures up to 250 pounds and are tested to 700 pounds pressure per square inch.

As the accompanying cuts will show, they embody several new and valuable features in their construction which will be readily appreciated.

The renewable parts are made of hard composition. They are especially suitable for high pressures.

By unscrewing the nut on bottom of valve all parts are accessible and removable from the top, thus making it convenient to substitute a new seat or new disc when required, or to replace any worn part.

The disc, being attached to the stem by a slot, is easily removed and replaced.

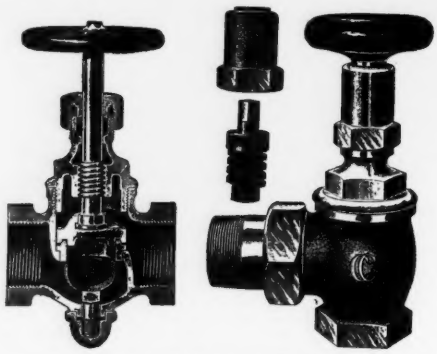
The seat and disc can be removed and the two ground together if necessary.

In putting together, replace the seat, then tighten the nut on bottom of valve, which holds the seat in place; then screw on the bonnet and close the valve.

The construction of these valves is such that they may be packed when open without steam escaping; to do so, have valve wide open.

The Crane "Self-packing" Globe and Angle and Radiator valves are made with Jenkins Disc and Non-rising Stem, and satisfactorily supply a demand for valves embodying this very desirable self-packing feature.

All users of radiator valves know that leaky stuffing boxes are a source of annoyance. The Crane Self-packing Radiator Valves obviate this trouble, for instead of two metallic parts grinding together, a piece of vulcanized rubber has been introduced which makes a perfect seat. This vulcanized rubber disc is easily renewed if necessary.



Crane Renewable Seat and Disc Valves

This self-packing device if desired, can also be applied to any of the Crane Co. Brass Wedge Gate Valves, with non-rising stem.

Belts for driving dynamo electric machinery should be made endless. A laced joint will cause a fluctuation in the voltage every time it passes over the dynamo pulley.

National President of the N. A. S. E. Welcomed.

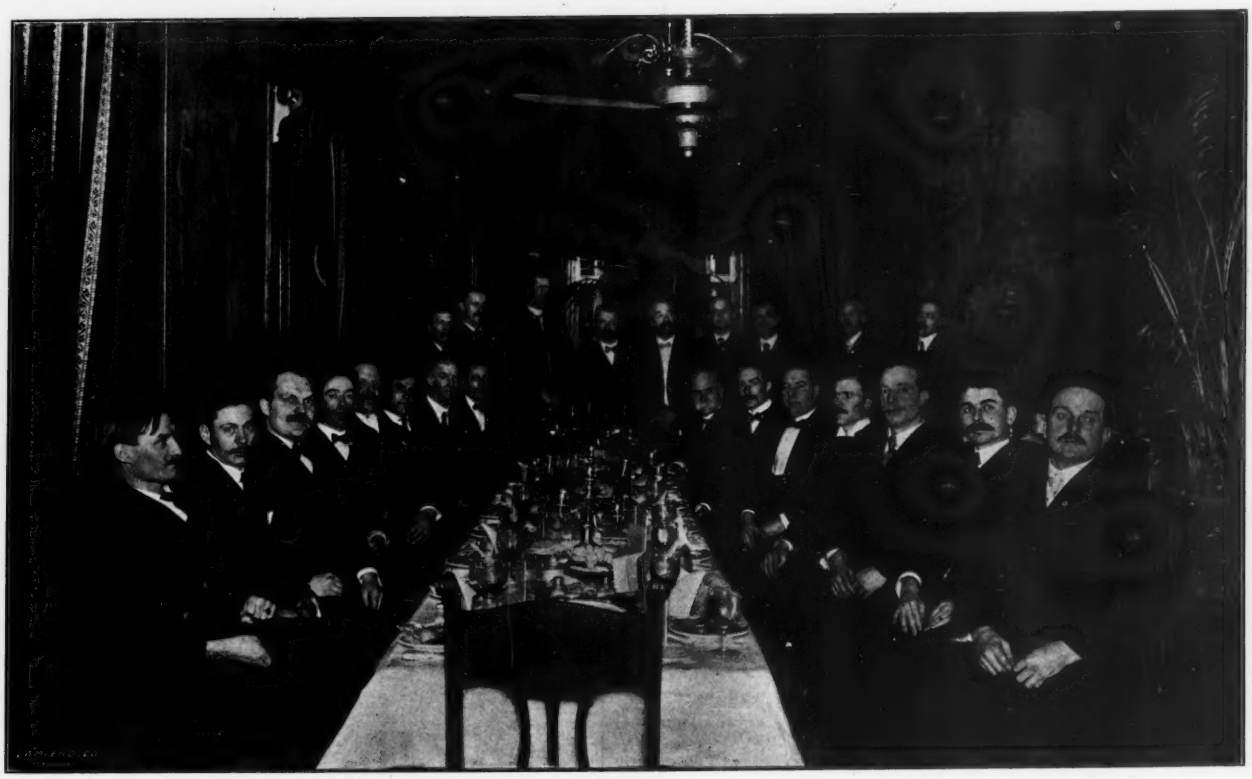
A combined meeting of N. A. S. E. societies of Philadelphia was held in the Assembly Room at the Philadelphia Bourse, on the evening of February 2nd, for the purpose of welcoming National President, Clare F. Wilson, and National Secretary, Fred W. Raven. The meeting was attended by over 200 engineers and their friends and the visitors were given a royal reception.

The address of welcome was made by Mr. George E. Bartol, President of the Bourse, in which he said that while he is not now an engineer, his early days were spent in and around machine shops where engines were built. He also read several letters which were written to him many years ago by his father, on the qualifications necessary for a successful engineer, which were particularly adapted to the occasion, as his father was the head of the Merrick's engine works for whom Merrick Association of the N. A. S. E. was named.

National President Wilson made a very comprehensive address on the value of education among engineers, their relations to their employers, and the important position they occupied in the business world, in which he said that the time has now come when the stationary engineer must be ranked with his more technically educated brother in the estimation of the world.

Mr. Alba Johnson, of the Baldwin Locomotive Works, made an address which was listened to with marked attention. Mr. Johnson explained the indenture system as applied to apprentices at their plant and pointed out that the man of the future is the one whose practical knowledge is combined with technical training. Prof. Arthur J. Rowland, of the Drexel Institute, which institution was visited by President Wilson, made a few remarks on the value of technical training to the engineer, as seen from his standpoint.

The meeting became more humorous when Mr. Raven interspersed his remarks with some funny stories, after which John D. Jones, Secretary of the National Association of Supply Men, convulsed the meeting by telling a number of his famous jokes. Mr. Jones also predicted what the program would be for the next National Convention to be held in Louisville.



DINNER GIVEN IN HONOR OF N. A. S. E. PRESIDENT C. F. WILSON AND SECRETARY F. W. RAVEN AT PHILADELPHIA

Sam'l. Hibbs C. W. Snyder President Wilson Richard Pape Secretary Raven John M. Lukens James Gillespie Sydnew Pellew A. J. Rowland
J. W. Wetherel Ed. Greene M. J. Malloy Wm. Rice Richard E. Calvert
John Landolt Enoch Carless Albert Munzinger John E. Frigar Walter Reading
P. O. Johnston John Wollin E. Caldwell Clinton E. Shaw G. Frank Deumler

The committee in charge of the reception were Richard Pape, P. O. Johnston and Sydney Pellew, representing Quaker City Association, No. 1, N. A. S. E.; Wm. Kane, Wm. Roth, and Wm. Fulmer, representing Tacony Association, No. 9; Chas. W. Snyder, John McMullen and John Tandolt, representing Merrick Association, No. 12; Ed. Greene, M. J. Malloy and G. F. Duemler, representing Northeast Association, No. 20.

Before the meeting at the Bourse, the above committee gave a dinner in honor of President Wilson and Secretary Raven at the Hotel Hanover, to which were invited a number of prominent engineers of this city. While in Philadelphia, President Wilson and Secretary Raven made a social call at the offices of "The Practical Engineer."

Municipal Council.

Municipal Council, No. 20, A. O. S. E., which is composed exclusively of engineers in the Philadelphia Fire Department, recently presented a set of engrossed resolutions to Mr. J. W. Weaver. Superintendent of the High Pressure Pumping Station, in appreciation of several very instructive lectures delivered before their Council. The engrossing committee consisted of Fred. Markoe, Michael Hartman and Harry Jones.

Book Review.

Modern Electricity, by James Henry and K. J. Hora. Size, 4½ x 6½. 360 pages and 150 illustrations. Laird and Lee, Publishers, 263 Wabash Avenue, Chicago. Price, $1.00.

This book has been prepared with a view of meeting any emergency that might confront the electrical engineer and inventor and a careful reading seems to prove that it has accomplished its object. It is well written and so classified that every subject can be easily found and when found, its statements are direct, leaving no doubt in the mind of the reader what is meant. This is a refreshing change over most books of its kind.

Besides the many illustrations, the book is full of good tables and formulas. Each formula is explained in the clearest manner possible and the process of arriving at results is clearly shown. It is one of the best and most comprehensive books on electrical engineering for the student, apprentice and artisan that we have seen.

Jerry Leahy Killed.

EDITOR THE PRACTICAL ENGINEER:

Please don't send "The Practical Engineer"; papa is dead.
Perth Amboy, N. J. LORETTA LEAHY.

The above brief but immeasurably pathetic note conveyed to us the first information of the recent death, by accident, of our long-time friend and contributor, Jerry Leahy, Jr. His death occurred at Mattewan, N. J., and was the result of a fall from a scaffold while he was endeavoring to loosen a rusty bolt with a large wrench. The bolt suddenly twisted off, throwing him to the ground, killing him instantly. Mr. Leahy was an engineer and a mechanic of marked ability. He was for many years an earnest and active member of the American Order of Steam Engineers and was well known to many of our readers, all of whom will share our regret at the loss of so good a man as well as our sincere sympathy with the bereaved family.

The total output of crude petroleum since it was first discovered in quantity in 1859 to the end of the year 1902, amounted to 1,165,290,248 barrels. If the barrels, estimated at 30 inches high, required to hold this oil were laid so that their heads would touch, they would encircle the earth 2.28 times. Considered as fuel, this oil is equivalent to about 330,000,000 tons of average coal.

The number of alternations per minute in an electric circuit can be obtained by multiplying the number of pole-pieces in the field magnet by the number of revolutions of the armature per minute.

This Book Free

Send us Three Subscriptions to The Practical Engineer at Fifty Cents each and we will send you Free a copy of

Hand Book of Corliss Steam Engines

BY FRANK WILLIAM SHILLITTO, JR.

This book describes, in a comprehensive manner, the Erection of Steam Engines, the Adjustment of Corliss Valve Gear, and the Care and Management of Corliss Steam Engines. It is illustrated by 64 Original Engravings. 200 Pages.

Price, $1.00, or will be sent Free for a Club of Three Subscribers to The Practical Engineer at 50 cents each.

We also have other books which we give as premiums for clubs of subscribers.

AGENTS WANTED. We want a few good agents to solicit subscriptions for The Practical Engineer on liberal commission basis. Hustlers can make good money. Write for terms, stating qualifications, experience, etc.

The Practical Engineer is the largest and best mechanical journal ever published anywhere in the world for fifty cents a year, and getting subscriptions for it is just like finding money.

Address Department A.

The Practical Engineer

46 N. TWELFTH ST., PHILADELPHIA, PA.

WRITE FOR OUR BOILER COMPOUND PROPOSITION

IT WILL PAY YOU

Continental Chemical Co.

2923 N. Broad Street PHILADELPHIA

Analytical Chemists and Manufacturers of Boiler Compounds.